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DISEASES OF THE EAR

MACMILLAN AND CO., Limited
LONDON · BOMBAY · CALCUTTA
MELBOURNE

THE MACMILLAN COMPANY
NEW YORK · BOSTON · CHICAGO
ATLANTA · SAN FRANCISCO

THE MACMILLAN CO. OF CANADA, Ltd.
TORONTO

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A PRACTICAL HANDBOOK

OF THE

DISEASES OF THE EAR

FOR SENIOR STUDENTS & PRACTITIONERS

BY

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WITH 293 ILLUSTRATIONS AND 6 COLOURED PLATES

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15/2/18.

MACMILLAN AND CO., LIMITED
ST. MARTIN'S STREET, LONDON
1911

TO
THE FELLOWS AND MEMBERS
OF
THE OTOLOGICAL SECTION OF THE ROYAL SOCIETY
OF MEDICINE

PREFACE

Recent progress in the diagnosis and treatment of Diseases of the Ear, and the greater attention paid to the subject by the senior student of Medicine and by the general practitioner, appear to the authors to justify the production of a Practical Handbook in which these various advances are recorded.

In the following pages special attention has been directed to emphasising the value of the application of pathological data—shorn as far as possible of technicalities—to accurate diagnosis and efficient treatment, and to the importance of co-operation between the practical surgeon and the clinical pathologist.

A short chapter upon those diseases of the nasal cavities which have a special bearing upon diseases of the ear has been added. No attempt has, however, been made to make this an exhaustive account of diseases of the nose. It has been inserted in order to draw the reader's attention to the important interdependence of aural and nasal lesions.

While gratefully acknowledging the valuable assistance derived from a careful study of the now extensive literature devoted to diseases of the ear, the authors have endeavoured to record the results of their own practical experience.

They are indebted to Dr. Purves Stewart for the chapter devoted to Diseases of the Ear in relation to General Medicine; to Dr. Thomas Guthrie for Illustrations 91 and 92; to Messrs. Macmillan and Co., Limited, for Plate V. from Allbutt and

Rolleston's *System of Medicine*; to Messrs. Longmans, Green, and Co. for the Illustrations from Quain's *Anatomy*; to Messrs. J. Wright and Sons for Illustrations 267-273; and to *The Practitioner* for Illustrations 233 and 234.

They desire to thank Messrs. Mayer and Meltzer and Messrs. Allen and Hanbury, Limited, for the Illustrations of the various instruments described in the Text, Messrs. Macmillan and Co., Limited, and Messrs. R. and R. Clark, Limited, the publishers and printers, for many acts of courtesy.

May 1911.

CONTENTS

CHAP. PAGE

I. THE DEVELOPMENT OF THE EAR 1
  1. The internal ear or labyrinth 1
  2. The auditory nerve and its ganglia 1
  3. The external and middle ear 2

II. THE ANATOMY OF THE EXTERNAL EAR 4
  1. The auricle 4
  2. The external auditory meatus 7
    (*a*) The cartilaginous meatus 7
    (*b*) The osseous meatus 7
    (*c*) The vessels and nerves of the auricle and external auditory meatus 8
    (*d*) The structures in relation with the auditory meatus . . 9
  3. The ear at birth 10

III. THE PHYSIOLOGY OF THE SOUND-CONDUCTING APPARATUS . . 13

IV. THE CAUSATION OF DISEASES OF THE EAR 18

V. THE EXAMINATION OF THE EAR, NOSE, NASO-PHARYNX, AND PHARYNX 22
  Objective examination 23
  Source of light 23
  Reflecting mirror 23
  Aural specula 24
  Magnifying aural speculum 25
  Method of using speculum and mirror 25
  Siegle's pneumatic speculum 25
  Ear cough 26
  Syringing the ear 27
  Examination of the external auditory meatus and membrana tympani . 28
  Clinical divisions of the membrana tympani 29
  Tests for and estimation of the hearing power 30
    Testing with the acoumeter 30
    The speech test 31
    Testing with a watch 31
    Testing with tuning-forks 32
    Testing with Galton's whistle 34
    Testing with the Galton-Edelmann whistle 34

CHAP. PAGE

- Testing with König's rods . . . 34
  - Schwabach's test . . . 34
  - Weber's test . . . 35
  - Rinné's test . . . 36
  - Gelle's test . . . 36
  - Bing's test . . . 37
  - Bárány's noise apparatus . . . 38
  - International acoumetric formula . . . 38
- Examination of the middle ear . . . 41
  - Valsalva's method of inflation . . . 41
  - Politzer's method of inflation . . . 42
  - Catheterisation of the Eustachian tube . . . 44
  - Bonnafont's method . . . 45
  - Loewenberg's method . . . 46
  - Lincke's method . . . 46
  - Effects of inflation upon audition . . . 49
  - Catheterisation from opposite nasal passage . . . 49
  - Catheterisation through the mouth . . . 50
  - Injection of fluids into the middle ear . . . 51
  - Method of making intra-tympanic injections . . . 52
- Massage of the membrana tympani and ossicular chain . . . 53
  - Paracusis Willisii . . . 54
  - Diplacusis . . . 55
  - Paracusis loci . . . 55
  - Hyperacusis . . . 55
  - Testing very deaf patients . . . 55
  - Local anaesthesia . . . 55
- Examination of pharyngeal, nasal, and naso-pharyngeal cavities . . . 58
  - Position of patient and examiner . . . 59
  - Pharyngoscopy . . . 59
  - Anterior rhinoscopy . . . 60
  - Posterior rhinoscopy . . . 61
  - Digital exploration of post-nasal space . . . 65

VI. DEFORMITIES OF THE EXTERNAL EAR . . . 66

- 1. Developmental . . . 66
- 2. Traumatic deformities . . . 67
- 3. Supernumerary auricles . . . 69
- 4. Deformity of the auricle . . . 69
  - Microtia . . . 69
  - Macrotia . . . 70
- 5. Outstanding auricle . . . 70
- 6. Fistula auris congenita . . . 71

VII. INJURIES OF THE AURICLE AND EXTERNAL AUDITORY MEATUS . . . 73

- 1. Auricle . . . 73
- 2. External auditory meatus . . . 74

VIII. DISEASES OF THE AURICLE . . . 76

- 1. Furuncular inflammation of the auricle . . . 76
- 2. Frost-bite . . . 76

CHAP. PAGE

3. Ossification of the auricle 77
4. Cysts of the auricle 77
    (a) Retention cysts 77
    (b) Dermoid cysts 77
    (c) Serous cysts 78
5. New formations 78
   Benign growths 79
    (a) Fibromata 79
    (b) Papillomata 79
    (c) Angiomata 80
    (d) Osteo-chondromata 82
6. Malignant disease of auricle 83
    (a) Epithelioma 84
    (b) Sarcoma 86
    (c) Endothelioma 86
7. Gouty deposits 87
8. Hyperaemia of auricle 88
9. Dermatitis of auricle 89
10. Erysipelas of auricle 89
11. Noma 91
12. Hyperaesthesia and anaesthesia of auricle 92
13. Eczema of auricle and auditory meatus 93
    (a) Acute eczema 93
    (b) Chronic eczema 94
14. Herpes auricularis 98
    Herpes gangrenosus hystericus 100
15. Lupus 100
    (a) Lupus vulgaris 100
    (b) Lupus hypertrophicus 102
    (c) Lupus erythematosus 102
16. Syphilitic affections of the external ear 105
    Primary 105
    Secondary 105
    Tertiary 105
17. Haematoma auris 108
    (a) Spontaneous 108
    (b) Traumatic 109
18. Perichondritis of auricle 111
    (a) Acute perichondritis 112
    (b) Chronic perichondritis 112

IX. Foreign Bodies in the Ear Cleft 114
  (a) In the external auditory meatus 115
  (b) In the middle-ear cleft 119

X. Diseases of the External Auditory Meatus . . . 121
  1. Hypersecretion and formation of ceruminous plugs . . . 121
  2. Keratosis obturans 124
  3. Deficient secretion of cerumen 125
  4. Otitis externa circumscripta 126
  5. Otitis externa diffusa 130

CHAP. PAGE

6. Otitis externa haemorrhagica 131
7. Spontaneous haemorrhage from the auditory meatus . . 132
8. Vicarious haemorrhage 132
9. Otitis externa crouposa 133
10. Otitis externa diphtheritica 134
11. Otitis externa parasitica 135
12. Osseous tumours in the auditory meatus 137
    Hyperostosis 137
    Exostosis 138
13. Stricture of the external auditory meatus 143
14. Caries and necrosis of the external auditory meatus . . . 145

XI. THE MIDDLE EAR OR TYMPANUM 147
- Anatomy of the middle ear 148
- The roof or tegmen tympani 148
- The floor of the middle ear 149
- The tympanic membrane 149
- Arterial supply of tympanic membrane 151
- Nerve supply of tympanic membrane 151
- Relation of the tympanic membrane to the inner wall of the tympanum 151
- The mastoid antrum 154
  - The Eustachian tube 155
  - The lining membrane of tympanic cavity 156
  - Pouches of the tympanum 157
  - The ossicles 158
  - The articulations of the ossicles 159
  - The ligaments of the ossicles 160
  - The tensor tympani muscle 161
  - The stapedius muscle 161
  - The vascular supply of the tympanum 161
  - The nerves of the tympanum 163
  - The communications of the antro-tympanic cavity . . 163
- The development of the petro-mastoid 164
  - The infantile type of temporal bone 165

XII. INFLAMMATORY AFFECTIONS OF THE MEMBRANA TYMPANI . . 167
- Acute myringitis 167
- Chronic myringitis 169

XIII. TRAUMATIC LESIONS OF THE MEMBRANA TYMPANI . . . 170

XIV. EXUDATIVE CATARRH OF THE MIDDLE EAR 175
- Aetiology 175
- Pathology 175
- Symptoms 176
- Diagnosis 178
- Prognosis 178
- Objective indications 178
- Treatment 179
- Catarrhal inflammation of the Eustachian tube 183
- Purulent inflammation of the Eustachian tube 184
- Stricture of the Eustachian tube 185

CHAP. PAGE

XV. CHRONIC ADHESIVE CATARRH OF THE MIDDLE EAR . . . 187

- Aetiology 187
- Pathology 188
- Subjective symptoms 189
- Objective indications 190
- Prognosis 191
- Differential diagnosis 191
- Treatment (local and general) 192
- Treatment of nasal and naso-pharyngeal mucosa . . . 194
- Operative treatment 195
- Artificial perforation of membrana tympani 195
- Division of posterior fold of membrana tympani . . . 196
- Tenotomy of tensor tympani muscle 196
- Tenotomy of the stapedius muscle 197

XVI. ACUTE SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR . . 198

- Exciting causes 198
- Predisposing causes 198
- Pathology 199
- Symptoms 201
- Appearances following perforation 204
- Prognosis 205
- Treatment 205
- Bier's induced hyperaemia 207
- Terminations 210
- Complications 210

XVII. EPITYMPANIC SUPPURATION WITH PERFORATION OF THE MEMBRANA FLACCIDA SHRAPNELLI 212

- Symptoms 214
- Treatment 214
- Ossiculectomy 217
  - Ludewig's operation 219
  - Zeroni's operation 219
  - Extraction of the stapes 220

XVIII. CHRONIC SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR . 221

- Morbid anatomy 223
- Symptomatology 225
- Objective appearances 227
- Prognosis 228
- Treatment 231
- Post-suppurative residua 238
  - Adherent cicatrices 238
- Treatment of dry perforations 239
- Artificial tampons 241
- Artificial aids to hearing 242

CHAP. PAGE
XIX. CYTOLOGICAL AND BACTERIOLOGICAL EXAMINATION OF DISCHARGES FROM THE EAR 244
Collection of material 244
Staining 245
Haematology in aural disease 261

XX. AURAL POLYPI 263
Pathology 264
Symptoms 266
Terminations 267
Diagnosis 267
Prognosis 268
Treatment 268
Granulomata 272
Non-specific type 272
Tuberculoma 274
Lupus granuloma 275
Syphilitic granuloma 275
Spirochaeta pallida 276

XXI. CHOLESTEATOMA 279
Pathology 280
Macroscopic features 282
Symptoms 284
Diagnosis 284
Prognosis 285
Treatment 285

XXII. TUBERCULOUS DISEASE OF THE MIDDLE EAR AND ITS ACCESSORY CAVITIES 287
Primary tuberculosis 287
Secondary tuberculosis 288
Symptoms 288
Pathology 291
Diagnosis 294
Treatment 297

XXIII. EAR AFFECTIONS IN THE COURSE OF TYPHOID AND OTHER SPECIFIC FEVERS 299
In typhoid fever 299
In measles 300
In influenza 301
In scarlatinal diphtheria 301

XXIV. FATAL HAEMORRHAGE FROM THE EAR 303

CHAP. PAGE

XXV. DISEASES OF THE MASTOID PROCESS 305

- Primary periostitis 305
- Secondary periostitis 305
- Acute primary inflammation of mastoid cells . . . 308
  - Catarrhal 309
  - Purulent 309
- Acute purulent inflammation of mastoid cells (secondary) . . 311
- Operation for acute suppurative endomastoiditis . . . 316
- Chronic purulent inflammation of the mastoid cells . . 321
  - (*a*) Indications for opening up mastoid cells . . . 321
  - (*b*) The radical mastoid operation 323
    - Körner's flap 329
    - Panse's flap 330
    - Stacke's flap 330
    - Siebenmann's flap 331
    - Milligan's flap 332
    - Brühl's flap 332
  - (*c*) Stacke's operation 333
  - (*d*) Wolf's operation 335
  - (*e*) Ballance's operation 335
    - Skin grafting 336
    - Intra-auricular transplantation of skin grafts . . 341
    - Latent mastoiditis 341
    - Bezold's mastoiditis 342
    - Diabetic mastoiditis 343
    - Plastic operations for closure of retro-auricular fistula . 344
      - Mosetig-Moorhof operation 345
      - Passow-Trautmann operation 346
      - Alexander's operation 347

XXVI. MALIGNANT AND SYPHILITIC DISEASE OF THE MIDDLE-EAR CLEFT 348

XXVII. FACIAL PARALYSIS 352

- Symptoms 354
- Prognosis 356
- Treatment 356
- Facio-accessory anastomosis 358
- Facio-hypoglossal anastomosis 359
- After-treatment 360

XXVIII. TINNITUS 361

- Character 361
- Pathology 362
- Pathogenesis 363
- Differential diagnosis 363
- Prognosis 363
- Treatment 364
- Motor neuroses of auricle and tympanum 364

CHAP. PAGE
XXIX. THE INTRA-CRANIAL COMPLICATIONS OF MIDDLE-EAR DISEASE . 366
1. General considerations 366
2. Pachymeningitis externa circumscripta 372
Bacteriology of extra-dural abscess 373
Symptoms and diagnosis 373
Terminations 375
Treatment 375
3. Purulent meningitis 376
Pathology 377
Symptoms 378
Diagnosis 380
Prognosis 381
Treatment 381
4. Meningitis serosa 384
Symptoms 384
Diagnosis 384
Treatment 385
Lumbar puncture 385
5. Epidemic cerebro-spinal meningitis 386

XXX. BRAIN ABSCESS 389
Pathology 390
Wall and contents of a brain abscess 391
Foetor of brain abscess 394
Cerebro-spinal fluid 395
Haematology 396
Meninges and ventricles 396
Channels of infection 397
Diagnosis 399
Temporo-sphenoidal abscess 400
Symptoms 400
Treatment 404
Terminations 408
Prognosis 408
Cerebellar abscess 408
General symptoms 411
Focal symptoms 414
Terminations 415
Prognosis 415
Treatment 416
After-treatment 418

XXXI. SINUS PHLEBITIS AND SINUS THROMBOSIS 419
Pathology 421
Symptoms 422
Diagnosis 424
Prognosis 425
Complications 425
Treatment 425

CHAP. PAGE
Grunert's operation 430
Piffl's operation 430
After-treatment 431

XXXII. THE ANATOMY OF THE INTERNAL EAR 433

The osseous labyrinth 433
The vestibule 434
The cochlea 434
The semicircular canals 435
The internal auditory meatus 435
The vascular supply of the labyrinth 436
The membranous labyrinth 437
The utricle 437
The cochlear tube 439
The organ of Corti 442
The rods of Corti 443
Distribution of cochlear and vestibular nerves . . . 444
The mode of continuity of the auditory sense epithelium with the auditory nuclei in the hind brain 445

XXXIII. DISEASES OF THE LABYRINTH 451

Foreword 451
Nystagmus 452
Hyperaemia of labyrinth 454
Aetiology 454
Pathology 455
Symptoms 455
Diagnosis 456
Treatment 456
Anaemia of labyrinth 456
Labyrinthine haemorrhage 457
Menière's disease 458
Definition of 458
Aetiology 458
Pathology 458
Symptoms 459
Diagnosis 459
Course of disease 459
Treatment 460
The labyrinth in leukaemia 460
Syphilis of the labyrinth 460
Pathology 461
Diagnosis 461
Prognosis 463
Treatment 463
Wassermann's test for syphilis 463

CHAP. PAGE

XXXIV. OTO-SCLEROSIS 465
- Definition of 465
- Pathogenesis 465
- Exciting causes 466
- Pathology 467
- Aetiology 468
- Symptoms 469
- Diagnosis 470
- Treatment 471
- Mobilisation of the stapes 473
- Extraction of the stapes 474

XXXV. INFLAMMATION OF THE LABYRINTH 476
- Primary inflammation of the labyrinth 476
  - Prognosis of 477
- The surgical treatment of non-suppurative affections of the labyrinth 478
  - Division of the auditory nerve 478
  - Extirpation of the cochlea 479
- Panotitis 480
- Suppuration of the labyrinth 480
  - Aetiology 481
  - Morbid anatomy and pathology 482
  - Acute suppurative pyo-labyrinthitis 482
  - Chronic suppurative pyo-labyrinthitis 484
  - Symptomatology 485
  - Terminations 488
  - Complications 488
  - Treatment 488
  - Jansen's operation 490
  - Neumann's operation 490
  - Botey's operation 490
  - Hinsberg's operation 490
  - Milligan's operation 491
  - Superior vestibulotomy 492
  - Inferior vestibulotomy 493
  - Double vestibulotomy 494

XXXVI. DISEASES OF THE EAR IN RELATION TO GENERAL MEDICINE . 496
- Gross intra-cranial lesions associated with auditory phenomena . 496
- Vascular lesions 496
- Cerebral embolism 496
- Cerebral thrombosis 496
- Sub-cortical or pure auditory aphasia 497
- Intra pontine vascular lesions 498
- Meningitis 498
- Intra-cranial tumours 499
- Tumours of the cerebral cortex 499
- Tumours of the cerebellum 500
- Tumours of the lateral lobe 500
- Extra-cerebellar tumours 500

CHAP. PAGE
Intra-cerebellar tumours of the lateral lobe 501
Tumours of the vermis 501
Tumours of the pons 501
Tabes dorsalis 501
Disseminated sclerosis 501
Epilepsy 502
Hysteria 502
Neurasthenia 502
Insanity 503

XXXVII. INJURIES AFFECTING THE INTERNAL EAR 505

XXXVIII. DEAF-MUTISM 507
Congenital deaf-mutism 507
Acquired deaf-mutism 507
Aetiology 507
Pathology 507
Differential prognosis 509

XXXIX. AURAL DISEASE AND LIFE INSURANCE 511
Simulated deafness 512
Requirements in regard to the ear and hearing of applicants for enlistment into the Army and Navy of Great Britain . . 514

XL. DISEASES OF THE NOSE, NASO-PHARYNX, AND PHARYNX SPECIALLY LIABLE TO INVOLVE THE ORGAN OF HEARING . . 515
1. Acute catarrhal rhinitis 515
2. Acute purulent rhinitis 519
3. Membranous rhinitis 520
4. Traumatic membranous rhinitis 520
5. Nasal diphtheria 520
6. Chronic catarrhal rhinitis 521
7. Atrophic rhinitis 526
8. Rhinitis sicca non-foetida 530
9. Rhinitis caseosa 531
10. Intra-nasal obstructions 532
11. Permanent hypertrophies of the mucous membrane . . 533
12. New growths 533
13. Septal spurs 538
14. Intra-nasal adhesions 539
15. Dislocation of the triangular cartilage 540
16. Deviations of the septum nasi 540
17. Haematoma and abscess of septum 546
18. Rhinoliths 547
19. Congenital occlusion of the posterior choanae . . . 548

XLI. POST-NASAL CATARRH 549
Aetiology 549
Symptoms 549
Diagnosis 549
Prognosis 550
Treatment 550

CHAP. PAGE
XLII. POST-NASAL GROWTHS 551
Naso-pharyngeal adenoids 551
Aetiology 551
Diagnosis 553
Differential diagnosis 553
Treatment 554
Tumours of the naso-pharynx 556
Naso-antral polypus 557

XLIII. HYPERTROPHY OF THE FAUCIAL TONSILS 558
Finger enucleation 559
West's operation 559
Waugh's operation 560
Milligan's operation 562
Tonsillotomy rash 565
Anaesthetics in tonsil and adenoid operations . . . 566

XLIV. SUPPURATIVE DISEASE OF THE NASAL ACCESSORY SINUSES . 568
Aetiology 568
Symptoms and diagnosis 568
Treatment 572
Irrigation through the ostium maxillare 573
Puncture and irrigation through the alveolus . . . 573
Intra-nasal opening and irrigation 573
Caldwell-Luc operation 574
Anterior ethmoidal suppuration 575
Frontal sinus suppuration 577
  Opening of the sinus and provision of intra-nasal drainage . 579
  Drainage without obliteration of sinus 581
  Obliteration of the cavity with and without preservation of the "bridge" 582
Suppurative disease of the posterior ethmoidal cells and sphenoidal sinuses 584

INDEX 587

LIST OF ILLUSTRATIONS

COLOURED PLATES

FIG.

I.

FACING PAGE
1. Irregular microtia
2. Complete absence of meatus 67
3. Eczema of auricle

II.

1. Aspergillus niger
2. Aspergillus niger—"daisy-like bodies" 135
3. Penicillium glaucum

III.

1. Acute osteomyelitis of mastoid, showing myeloid cells
2. Acute suppuration of middle ear, showing leucocytes and a few lymphocytes 200
3. Acute catarrh of the middle ear (early stage), showing tympanic epithelium

IV.

1. Acute suppurative otitis media
    1. Tympanic epithelium. 2. Leucocyte containing diplococci
2. Chronic suppurative otitis media with caries 224
    1. Leucocytes. 2. Lymphocyte. 3. Staphylococci. 4. Leucocyte containing fragment of another nucleus and streptococci. 5. Myelocyte. 6. Spirochaetae

V.

Chronic suppuration of the middle ear
    Polypus auris
    Calcareous deposit. Cicatrix
    Perforation of posterior segment with exposure of the stapes 227
    Perforation in Shrapnell's membrane. Bare bone felt through perforation with probe

VI.

1. Discharge in chronic suppuration of the middle ear with cholesteatoma, acid-fast squames, leucocytes, lymphocytes, and spirochaetes 281
2. Plasma cells in a granuloma from the middle ear

FIGURES

FIG. PAGE
1. Cartilage of auricle (anterior aspect) 3
2. Outer aspect of auricle 4
3. Cartilage of auricle (lateral aspect) 5
4. Cartilage of auricle (mesial aspect) 5
5. Transverse section of auricle 6
6. Horizontal section to show floor of meatus with its curves . . . 7
7. Cartilaginous region of meatus 8
8. Osseous region of meatus, showing ceruminous glands . . . 9
9. Skull of a child at birth (under surface) 10
10. Annulus tympanicus and insertion of membrana tympani . . . 10
11. Squamo-tympanic bone of child (external aspect) 11
12. Squamo-tympanic bone of child (internal aspect) 11
13. Horizontal section of head of child at birth, showing continuity of middle-ear cleft 12
14. The squamo-zygomatic and petrous elements of temporal bone . . 12
15. Interlocking of the malleus and incus 15
16. Clar's photophore 23
17. Gardiner Browne's reflector 24
18. Gruber's specula 24
19. Pritchard's aural specula 24
20. Dundas Grant's magnifying aural speculum 25
21. Mirror with lens 25
22. Aural speculum *in situ* 25
23. Siegle's pneumatic speculum 26
24. Politzer's angular forceps 27
25. Milligan's aural probe 27
26. Wyatt Wingrave's syringe 27
27. Clinical divisions of membrana tympani 30
28. Politzer's acoumeter 30
29. Hartmann's tuning-forks 33
30. Galton's whistle 34
31. Galton-Edelmann whistle 34
32. Politzer's bag 42
33. Auscultation tube 43
34. Inflation of middle ear with Politzer's bag 43
35. Eustachian catheters 44
36. First step in introduction of Eustachian catheter 45
37. Eustachian catheter in mouth of Eustachian tube 46
38. Eustachian catheter *in situ* 47
39. Ear manometer 49
40. Baber's Eustachian catheter 50
41. Faulty method of passing Eustachian catheter 51
42. Weber-Liel's intra-tympanic tube 52
43. Lucae's pressure-probe 54
44. Delstanche's masseur 54
45. Neumann's syringe 56
46. Wingrave's post-nasal cannula 58
47. Turck's tongue depressor 60
48. Sagittal section of nasal cavity (wet preparation) 61

FIG. PAGE
49. Sagittal section of nasal cavity (dry preparation) 62
50. White's palate retractor 63
51. Hays' pharyngoscope 64
52. Hays' pharyngoscope *in situ* 65
53. Congenital malformation of auricle 66
54. Keloid of lobule 68
55. Microtia and congenital malformation of auricle 69
56. Malformed and outstanding auricle 71
57. Fracture of temporal bone (line of fracture) 74
58. Retention cyst of auricle 77
59. Keloid of auricle (microscopic section) 79
60. Papilloma of meatus 80
61. Cervical branchial fistulae with meatal papillomata . . . 81
62. Naevoid angioma of auricle 82
63. Naevoid angioma of auricle (microscopic section) 82
64. Primary osteo-chondroma of meatus 83
65. Epithelioma of the auricle and meatus 84
66. Squamous-celled carcinoma (retro-auricular) 85
67. Endothelioma of meatus 86
68. Endothelioma of meatus (microscopic section) 87
69. Herpes auricularis 98
70. Lupus of auricle 101
71. Primary syphilis of auricle (microscopic section) 105
72. Chancre of meatus (microscopic section) 106
73. Mucous patch from meatus (microscopic section) 107
74. Gummatous deposit in auricle and meatus (microscopic section) . . 108
75. Haematoma auris (traumatic) 109
76. Tröltsch's aural hook 117
77. Lister's ear hook 118
78. Displacement of auricle from furunculosis 128
79. Dundas Grant's furuncle knife 128
80. Ivory exostosis from tympanic bone (microscopic section) . . . 138
81. Cancellous exostosis of meatus (microscopic section) . . . 139
82. Cancellous exostosis (microscopic section) 140
83. Chronic periostitis of temporal bone (microscopic section) . . . 144
84. Temporal bone, viewed from below 147
85. Horizontal section of temporal bone, showing middle-ear cleft . . 148
86. Temporal bone, showing middle-ear cleft 148
87. Temporal bone, showing continuity of the cavities of the middle ear . 149
88. Temporal bone, showing attachment of membrana tympani . . 150
89. Vertical section through tympanic cavity 152
90. Section of temporal bone, showing antro-tympanic cavity . . . 153
91. Middle-ear cleft (4 months foetus) 154
92. Middle-ear cleft (7½ months foetus) 155
93. Vertical section of tympanic cavity 158
94. The ossicles 159
95. The stapes *in situ* 160
96. Chorda tympani nerve in middle ear 162
97. Diploetic mastoid process 164
98. Infantile type of temporal bone 165
99. Rupture of membrana tympani 172
100. Sero-mucous exudation into tympanic cavity 179

FIG. PAGE

101. Section of nose (wet preparation), showing pharyngeal opening of Eustachian tube 184
102. Retraction of membrana tympani 191
103. Acute suppuration of middle ear (section of tympanic mucous membrane) 199
104. Acute suppuration of middle ear, incision of membrana tympani 206
105. Paracentesis knife 206
106. Line of incision in "attic" suppuration 214
107. Milligan's intra-tympanic syringe 215
108. Removal of outer "attic" wall 216
109. Pfau's "attic" punch forceps 217
110. Incision for removal of membrana tympani 218
111. Delstanche's "extracteur du marteau" 219
112. Ludewig's incus hook 220
113. Zeroni's incus hook 220
114. Various shapes and sizes of perforation 229
115. Botey's aural mirror 238
116. Yearsley's pad 241
117. Yearsley's artificial tympanum, with introducer 241
118. Toynbee's artificial tympanum 241
119. Cystic aural polypus (microscopic section) 265
120. Aural polypus, myxoedematous fibroma 266
121. Aural polypus, seroedematous tissue 267
122. Granuloma, seroedematous formation 268
123. Wingrave's polypus forceps 271
124. Aural snare 271
125. Removal of polypus with snare 272
126. Granuloma simplex, non-specific (microscopic section) 273
127. Syncitial cells from granuloma of mastoid antrum (microscopic section) 274
128. Tuberculoma from meatus (microscopic section) 275
129. Capsule of cholesteatoma (microscopic section) 280
130. Capsule and lining of cholesteatoma (microscopic section) 281
131. Mycelia and spores from a cholesteatoma (microscopic section) 283
132. Tuberculosis of the incus 292
133. Tuberculosis of temporal bone (microscopic section) 293
134. Tuberculosis of temporal bone (microscopic section) 294
135. Tuberculosis in a guinea-pig 296
136. Acute suppurative mastoid periostitis (front view) 307
137. Acute suppurative mastoid periostitis (viewed from behind) 307
138. Mastoid fistula, bone granulations 315
139. Leiter's coil apparatus 316
140. Wilde's incision 317
141. Milligan's self-retaining mastoid retractor 317
142. Acute suppurative endomastoiditis. Operation cavity 318
143. Temporal bone, with mastoid cortex removed 319
144. Dundas-Grant's mastoid hook 319
145. Temporal bone, showing "supra-meatal triangle" 323
146. Temporal bone, showing Schwartze-Stacke operation 326
147. Diploetic mastoid process, with large apical cell 328
148. Temporal bones illustrating variations in the size of the jugular fossa 329
149. Korner's flap 330
150. Panse's flap 330
151. Stacke's flap 331

FIG. PAGE
152. Siebenmann's flap 331
153. Milligan's flap 332
154. Brühl's flap 332
155. Stacke's "guide" 334
156. Ballance's flap 336
157. Ballance's graft lifter 337
158. Ballance's pipette 337
159. Ballance's stoppers 338
160. Graft *in situ* 339
161. Squamo-mastoid portion of temporal bone 342
162. Mosetig-Moorhof operation (first step) 345
163. Mosetig-Moorhof operation (second step) 345
164. Passow-Trautmann operation (first step) 346
165. Passow-Trautmann operation (second step) 346
166. Passow-Trautmann operation (third step) 347
167. Alveolar epithelioma of middle ear (microscopic section) . . . 348
168. Angio-sarcoma of middle ear (microscopic section) 349
169. Myeloid sarcoma from mastoid (microscopic section) . . . 350
170. Fungating sarcoma of middle ear 351
171. Temporal bone, showing course of facial nerve 352
172. Temporal bone, showing opened-up aqueduct of Fallopius . . . 353
173. Relation of facial nerve to cochlea 354
174. Bilateral facial paralysis 356
175. Facio-hypoglossal anastomosis 358
176. Implantation of nerves. Method of suturing 359
177. Temporal bone, showing course of sigmoid sinus 366
178. Radiogram, showing course of lateral sinus 367
179. Caries of tegmen antri 368
180. Cario-necrosis of antro-tympanic roof 369
181. Carious erosion of tegmen antri 370
182. Erosion of tegmen antri 372
183. Apical cells of pars petrosa 374
184. Dorello's space 375
185. Plastic streptococcal infection of dura mater 377
186. Meningo-encephalitis 378
187. Trochar for lumbar puncture 385
188. Temporo-sphenoidal abscess 390
189. Temporo-sphenoidal abscess 391
190. Cerebellar abscess communicating with the 4th ventricle . . . 392
191. Acute encephalitis 392
192. Choroid plexus, from a case of serous meningitis 397
193. Choroid plexus (serous meningitis) 398
194. Choroid plexus (serous meningitis) 399
195. Perforation, tegmen antri and petro-squamosal suture . . . 400
196. Decussation of fibres 402
197. Incision for temporo-sphenoidal abscess 404
198. Dahlgren's forceps 405
199. Horsley's pus seeker 406
200. Whiting's encephaloscope 407
201. Cerebellar abscess 409
202. Large cerebellar abscess 410
203. Cerebellar abscess in right lobe 411

FIG. PAGE
204. Cerebellar abscess in left lobe 412
205. Temporal bone, showing cerebellar route 415
206. Temporal bone, showing cerebellar route (viewed from inner side) . . 416
207. Temporal bone ; caries of sigmoid groove 419
208. Section of temporal bone at level of groove for sigmoid sinus . . 420
209. Temporal bone ; erosion of sigmoid sinus groove 420
210. Diagram of jugular bulb and connections 421
211. Caries of sigmoid groove and large jugular fossa 421
212. Streptococcal infection of wall of sigmoid sinus 422
213. Cavernous sinus thrombosis 423
214. Right osseous labyrinth 434
215. Interior of left labyrinth 435
216. Osseous cochlea 436
217. Diagram of osseous cochlea 437
218. Section of temporal bone to show fossa of internal auditory meatus . 438
219. Diagram of membranous labyrinth (antero-lateral aspect) . . . 439
220. Diagram of membranous labyrinth (postero-mesial aspect) . . . 440
221. Section through middle of cochlea 441
222. Diagram of a spiral turn of the cochlea 442
223. Section through the organ of Corti 443
224. Diagram of crista acustica in an ampulla 444
225. Internal surface of temporal bone 445
226. Direct anatomical continuity of the auditory nerve fibres with cells of auditory nucleus 446
227. Fibrillation of auditory syncytium 447
228. Fibrillation of central end of auditory syncytium 448
229. Fibrillation of peripheral end of auditory syncytium . . . 448
230. The auditory sense epithelium 449
231. Mnemonic diagram of canalicular system 453
232. Endarteritis obliterans 462
233. Oto-sclerosis 466
234. Oto-sclerosis 467
235. Lake's incision for extirpation of cochlea 480
236. Routes of infection from middle to internal ear and from internal ear to interior of cranium 481
237. Sequestra from internal ear 483
238. Temporal bone, showing erosion of canal for facial nerve . . . 485
239. Fistulous opening in external semicircular canal 486
240. Bourguet's facial nerve protector 491
241. Milligan's facial nerve protector 491
242. Temporal bone, showing relation of semicircular canals to one another and to facial aqueduct 492
243. The complete "bridge" operation 493
244. Inferior vestibulotomy 493
245. Double vestibulotomy 494
246. Temporal bone, showing line of fracture 505
247. Woakes's nasal scissors 524
248. Carmalt Jones's spokeshave 525
249. Incision for removal of anterior end of middle turbinal . . . 526
250. Lake's syringe for intra-nasal injection of paraffin wax . . . 529
251. Exostosis from maxillary antrum 537
252. Exostosis from frontal sinus 538

FIG. PAGE
253. Bosworth's nasal saws 539
254. Gleason's operation 541
255. Incision for submucous resection of nasal cartilage 542
256. Ballenger's swivel knife 543
257. Brüning's septum splint 543
258. Asch's scissors 544
259. Asch's curved scissors 544
260. Incision in Asch's operation 544
261. Moure's scissors 545
262. Incisions in Moure's operation 546
263. Moure's forceps 546
264. Adenoid vegetation 552
265. Post-nasal curette 555
266. Naso-antral polypus 557
267. West's operation for enucleation of tonsils 559
268. West's operation for enucleation of tonsils 559
269. West's operation for enucleation of tonsils 560
270. West's operation for enucleation of tonsils 560
271. Waugh's operation for enucleation of tonsils 560
272. Waugh's operation for enucleation of tonsils 561
273. Waugh's operation for enucleation of tonsils 561
274. Milligan's operation for enucleation of tonsils 562
275. Milligan's operation for enucleation of tonsils 562
276. Milligan's knife for enucleation of tonsils 562
277. Enucleated tonsils (faucial and cervical aspects) 563
278. Section of enucleated tonsil (microscopic) 564
279. Sagittal section of nose 569
280. Killian's long nasal speculum 571
281. Lichtwitz's trochar and cannula 572
282. Caldwell-Luc operation (opening in canine fossa) 575
283. Caldwell-Luc operation (opening in external nasal wall) 576
284. Hajek's hook 576
285. Kuhn's per-oral intubation tube 577
286. Lake's frontal sinus cannula 578
287. Radiogram of normal frontal sinuses 579
288. Radiogram of suppurative frontal sinusitis 580
289. Killian's operation for frontal sinusitis 582
290. Killian's operation for frontal sinusitis 582
291. Killian's operation for frontal sinusitis 582
292. Septic osteomyelitis of frontal bone 583
293. Cannula passed through ostium sphenoidale 584

CHAPTER I

DEVELOPMENT OF THE EAR

General View

The organ of hearing is developed in three distinct and independent portions:—

1. The external and middle ear.
2. The internal ear or labyrinth.
3. The auditory nerve and its ganglia.

Both the external and the middle ear are formed from the first post-oral or hyomandibular cleft where epiblast and hypoblast meet.

The internal ear is developed as a distinct element by a downgrowth of the skin epiblast, which is first seen as a simple but well-marked depression—the otic pit or vesicle—at the hind extremity of the hyomandibular cleft. It is soon completely shut off from the surface as it sinks into the mesoblast towards the hind brain in a manner similar to the development of the lens. At first it is shaped somewhat like a trowel, the handle portion being called the *recessus labyrinthi*, which eventually becomes the *saccus endolymphaticus*, a structure destined to play an important part in intracranial infection (p. 410).

Internally to the otic vesicle an island of neuroblasts is projected from the neural epiblast, which forms the cochlear and vestibular ganglia together with their respective nerves, so establishing a connection between the vesicle and the hind brain.

At first the mesoblast around the vesicle is simply undifferentiated embryonic tissue, but later it becomes cartilaginous—the periotic capsule—to be succeeded by the bony labyrinth together with the petrous and mastoid portions of the temporal bone. The modiolus and septa of the cochlea are, however, formed without the intervention of cartilage.

The auditory vesicle soon becomes differentiated into an irregular tube, from whose ventral end a straight and subsequently twisted hollow is projected—the cochlear canal—while from its dorsal end the semicircular canals are formed. The tubes thus assume a labyrinthine shape, with the utricle and saccule intervening. The *recessus labyrinthi* eventually passes through the *aqueductus vestibuli* of the petrous bone, and terminates under the dura-mater as the *saccus endolymphaticus.*

As the skull develops, these epithelial tubes—the rudimentary membranous labyrinth—are separated from the enveloping cartilage by gelatinous embryonic tissue, which becomes the perilymph space, whilst the lining cells become variously modified in several parts to assume the special characteristic structures of hair cells, rods of Corti, cristae, maculae, etc.

The labyrinth retains rudimentary connection with adjacent cavities in several ways, the two most marked being the *ductus* and *saccus endolymphaticus*; the former is conveyed by the *aqueductus vestibuli* to the posterior cranial fossa, while the *ductus perilymphaticus* is enclosed in the *aqueductus cochleae.* Although both become obliterated, the former plays an important pathological rôle by forming a communication between the endolymph and the subdural space; while the latter, communicating with the inferior petrosal sinus and the local lymphatic vessels, forms a connection with the perilymph, but perhaps to a less important degree. There are also numerous connections with the subdural and arachnoid spaces by means of the perivascular lymph paths surrounding blood-vessels, and by the perineural sheaths, especially those of the seventh and eighth nerves.

The external and middle ear with the Eustachian tube are formed from and around the hyomandibular cleft by differentiation of its epithelial lining and its surrounding mesoblast. The bottom of the cleft is closed by the meeting of epiblast and hypoblast, between which an ingrowth of mesoblast forms a rudimentary tympanic membrane. Thus the Eustachian tube and the tympanum with its accessory spaces may be considered as a continuation or lateral expansion of the anterior extremity of the foregut, and definitely hypoblastic in origin; while the meatus, the auricle, and in fact all that is external to the tympanic membrane, including its dermic layer, are originally epiblastic or cuticular.

Around the primitive membrane in fibrous tissue is formed the incomplete bony tympanic ring, which, growing outwards, becomes the osseous meatus.

Connection between the tympanic membrane and the labyrinth is established by the ossicles, which are developed from the Meckelian or hyoid bar. The ossicles are at first excluded from the tympanic cavity proper; but on the gradual enlargement of the deep part of the cleft its gelatinous contents are absorbed, leaving the bones projecting into the cavity, which is not complete till birth. Even at that period portions of the jelly-like mesoblast may persist particularly around the malleo-incudal joint.

Note. There is some difference of opinion as to the origin of the ossicles and the tympanic ring. The latter is considered by some to be a representative of the quadrate bone of the lower vertebrates, whilst the malleus is undoubtedly derived from Meckel's cartilage, and the incus is said to belong to the hyoid cartilage. The stapes, although connected with that bar, has been attributed either to the periotic cartilage or to a special deposit around the vanishing stapedial artery.

The osseous meatus is chiefly formed from the tympanic bone, which at birth is a horseshoe-shaped ring incomplete at the top. This grows outwards from two or more points in the fibrous tissue connecting it with the auricle and eventually forms a thin curved plate. Later it blends with the squamous and petro-mastoid elements, which growing with it complete the canal.

The cartilaginous portion is formed in connection with the auricle by means of two or more curved plates separated by fibrous tissue—the fissures of Santorini (Fig. 1).

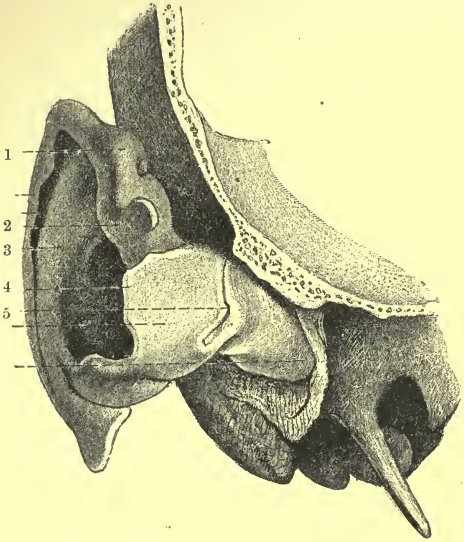

Fig. 1.—Cartilage of auricle, anterior aspect—(1) crus helicis, (2) spina helicis, (3) anthelix, (4) tragus, (5) incisura Santorini.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

The auricle continuous with the meatal cartilage is formed from eight mesoblastic thickenings or tubercles around the margin of the cleft, all of which become cartilaginous with the exception of the lobule.

CHAPTER II

ANATOMY OF EXTERNAL EAR

The external ear includes the auricle and the external auditory meatus which terminates at the tympanic membrane, where the cuticular epiblast meets with the hypoblastic antro-tympanic cavity or middle ear.

The auricle is a fibro-cartilaginous plate presenting ridges and depressions which are better marked in man than in the more mobile ears of quadrupeds. These features are represented in Fig. 2, and demand no detailed description. While exhibiting considerable racial and family differences, the most variable part is the lobule, which, although often only rudimentary, is the most marked characteristic of the human auricle.

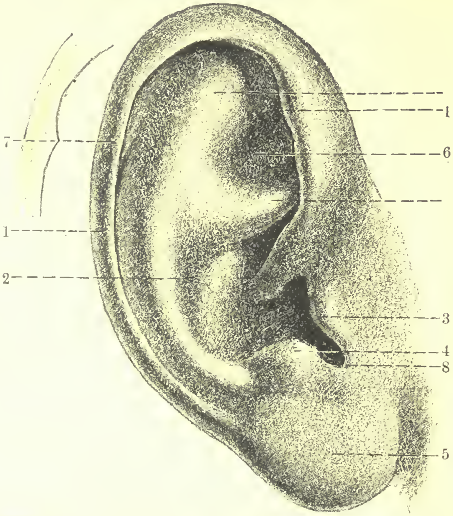

Fig. 2.—Outer aspect of auricle—(1) helix, (2) anthelix, (3) tragus, (4) antitragus, (5) lobule, (6) fossa triangularis, (7) tubercle of helix, (8) incisura intertragica. (From Quain's *Anatomy*, vol. iii. pt. iii.)

The cartilage is a complex plate (Figs. 3 and 4) giving shape to the whole of the auricle except the lobule, which only receives a small projection, the *processus caudalis*. With fibrous interruptions it is continued into the meatus. In thickness it varies from 1 to 3 mm., and presents a number of fissures and clefts, some of which are occupied by nerves and arteries.

Fig. 5 illustrates a section through the helix, and is typical of the whole auricle except the lobule, which is simply a mass of adipose tissue. Although closely applied to the cartilage, the skin is really separated from it by a well-marked stratum of finely reticular connective tissue containing large irregular vessels with thin walls, an arrangement which explains the formation of othaematomata. Extremely fine hairs, invisible to the naked eye, occur over the whole auricle, while over the inner aspect of the tragus, the anti-tragus, and outer part of the meatus they are large and coarse. Sebaceous glands are numerous, and, as elsewhere, accompany the hair follicles, while a few sweat glands are found on the mesial aspect, where the former structures are much fewer.

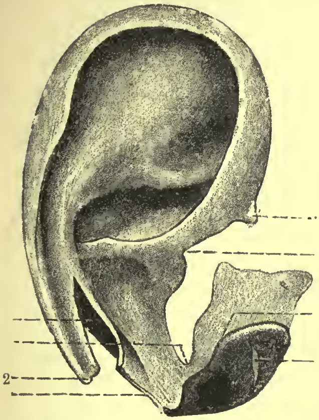

Fig. 3.—Cartilage of auricle, lateral aspect—(1) spina helicis, (2) processus caudalis, (3) tragus plate.

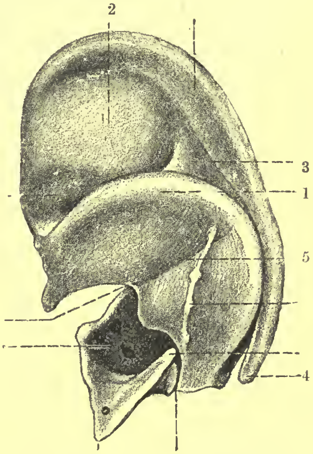

Fig. 4. — Cartilage of auricle, mesial aspect—(1) eminentia conchae, (2) eminentia fossae triangularis, (3) fossa of anthelix, (4) processus caudalis, (5) sulcus cruris helicis.

(From Quain's *Anatomy*, vol. iii. pt. iii.)

The cartilage belongs to the yellow fibrous variety in which elastic elements mingled with white fibres predominate. It varies, however, in certain situations, near its attachment to the bone becoming hyaline, while in the meatus white fibres are in excess of elastic. In some parts the cells are large, and show marked vacuolation and a tendency to cyst-like distension.

Covering the cartilage is a well-defined layer or membrane, the perichondrium, which consists of closely packed fusiform connective-tissue cells continuous with the stroma of the matrix, and in places forming strands or septa which pierce the cartilage. Lying in this perichondrium are bundles of medullated nerve fibres which in serial sections may be traced together with small arteries and perichondrial strands right through the cartilage. This arrangement of nerves explains the intensity of the pain which invariably attends perichondritis of the auricle, while the clefts further indicate the channels by which blood may pass when involving both aspects of the pinna as in othaematoma.

There are two ill-defined ligaments—an anterior which passes from the spine of the helix to the root of the zygoma, and a posterior which unites the back of the concha with the surface of the mastoid.

The muscles are as a rule only rudimentary, and are of slight clinical interest. They are supplied by the facial nerve.

The arterial supply is from two sources—the *posterior auricular*, a branch of the external carotid, which, after supplying its mesial aspect, pierces the cartilage, and is distributed to its external surface and to the lobule, while the *anterior auricular* from the superficial temporal chiefly supplies the lobule and tragus. Blood is returned by the posterior auricular and temporal veins.

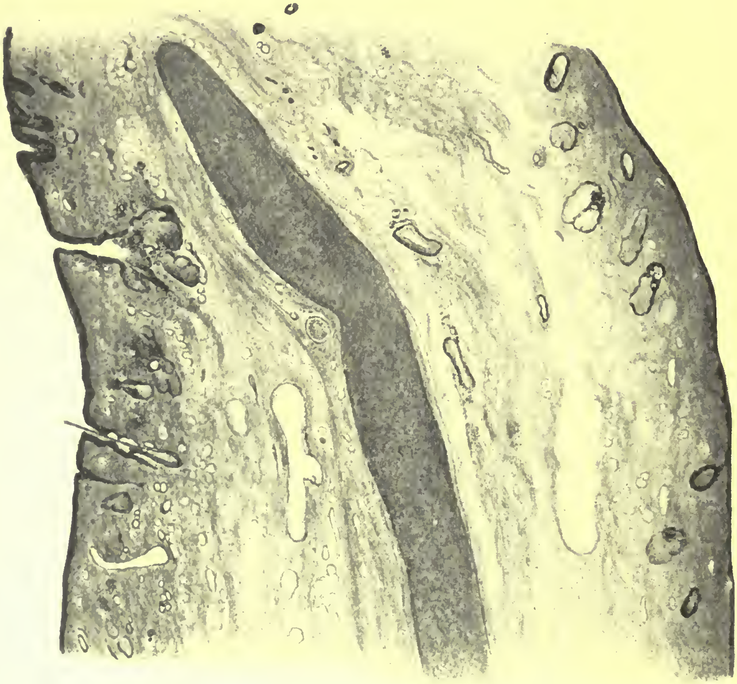

FIG. 5.—Section of auricle, showing cartilage with nerves in perichondrium, large vascular spaces, and reticular tissue.

There are three sets of lymphatics. One set terminates in the antetragal gland, a second in the mastoid or post-auricular glands, and a third in the parotid lymphatic glands.

The sensory nerves of the auricle are four in number :—

1. The *great auricular* from the cervical plexus, which, after supplying

the skin over its inner aspect, pierces the cartilage in company with the post-auricular artery, and distributes filaments to the lobule and the region just above it.

2. The *auriculo-temporal* branch of the fifth, which sends twigs chiefly to the outer surface of the pinna.

3. A branch from the small occipital, which supplies the upper cranial aspect.

4. The *auricular branch of the vagus*, which, after communicating with the facial twig, supplies the rest of the cranial aspect.

External Auditory Meatus (*Meatus acusticus externus*).—This canal is about 24 mm. long, but is subject to considerable variations in depth, direction, and calibre. Its posterior and superior walls are shorter than its inferior and anterior (Fig. 6).

It may be arbitrarily divided into three portions—an *external*, which is directed forwards and upwards; a *middle*, backwards and horizontally; and an *internal*, forwards and downwards.

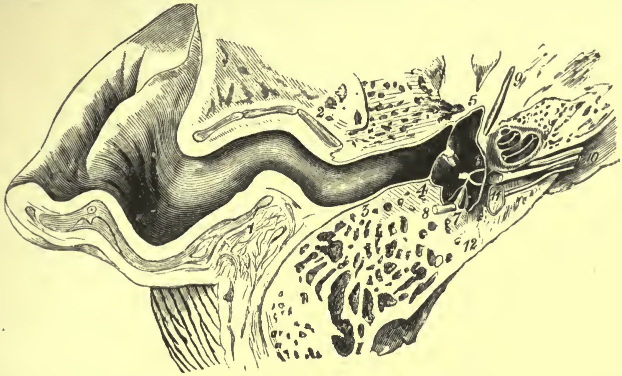

Fig. 6.—Horizontal section to show floor of the meatus with its curves. Left ear. (From Quain's *Anatomy*, vol. iii. pt. iii.)

Structurally there are two distinct parts—an *external* or cartilaginous, forming less than half the length of the canal and an internal or *osseo-fibrous*.

The external is bounded by a tubular prolongation of the auricular cartilage, which is deficient at its posterior superior part. It is covered by skin containing sebaceous glands and hair follicles, beneath which is a connective-tissue layer closely united to the perichondrium containing blood-vessels and nerves (Fig. 7). As in the auricle some of these vessels are very large and have thin walls.

In the internal or *osseous* part cartilage is absent, and the skin is intimately adherent to the periosteum, more closely, in fact, than with the perichondrium in its external portion.

Its lining differs entirely from that of the outer division in having no hairs and no sebaceous glands; but this line of separation is not very sharply marked, since hairs are not uncommon in portions of the roof. There is also some overlapping in the distribution of ceruminous glands (Fig. 8).

These appear as convoluted oval tubes lined with a single layer of cubical cells. The lumen is well marked, and contains a yellow material (*cerumen*) which is sometimes granular. They differ from sweat glands in their oval section and in their contents. Their ducts open either directly on to the surface or into hair follicles.

An occasional but somewhat rare feature is a corrugation of the cuticular lining due to a localised hypertrophy of the papillae, with thickening of the Malpighian layer of the epidermis, which is everywhere covered with a very thin zone of horny cells, *i.e.* squames containing keratin granules which are constantly being shed in quantities which vary with the health of the individual and with local conditions.

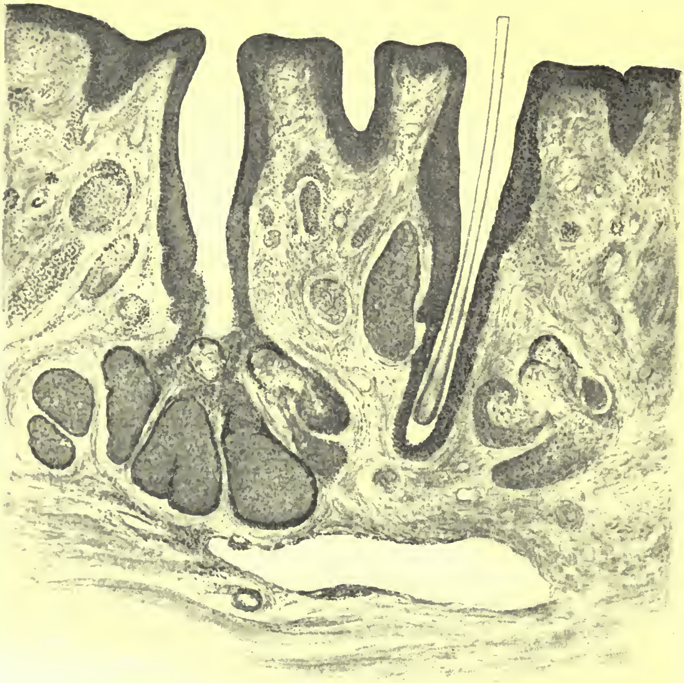

FIG. 7.—Cartilaginous region of meatus. Obj. $\frac{2}{3}$ in.

The arterial supply is derived from the posterior auricular, internal maxillary, and temporal arteries whose branches chiefly run along the upper and posterior part of the tube. The veins and lymphatics run as in the auricle.

The nerve-supply of the meatus is of the greatest importance, since differential diagnosis of the source of pain in referred otalgia depends so much upon accurate localisation. The fifth nerve supplies the whole of the lining of the innermost or osseous canal, together with the lower half of the tympanic membrane, while the auricular branch of the vagus is responsible for sensation in the upper half of the tympanic membrane and the cartilaginous meatus.

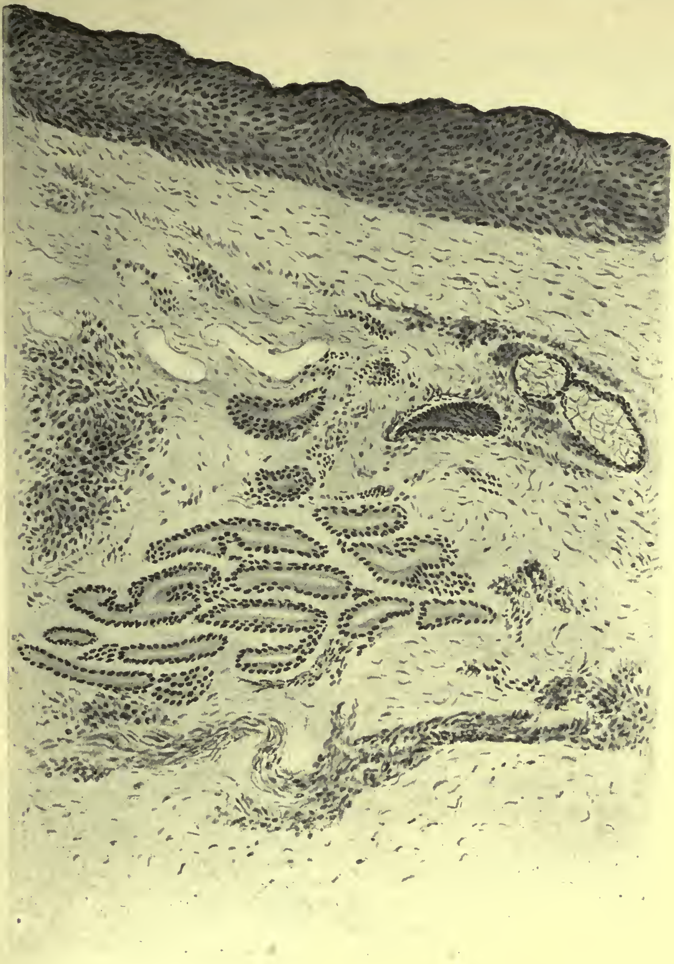

FIG. 8.—Section of osseous region of meatus showing ceruminous glands. Obj. ⅔ in.

The structures in relation with the meatus are—

Anteriorly, the parotid gland and temporo-mandibular joint.

Posteriorly, the mastoid cells, part of antrum, and sigmoid sinus.

Superiorly, the middle cranial fossa, and occasionally part of mastoid antrum and epitympanic floor.

Inferiorly, the temporo-mandibular joint.

In the adult a perpendicular line drawn through the centre of the osseous meatus corresponds with the plane of the posterior wall of the tympanic cavity.

The Infant's Ear.—The skull of the newly born, so far as the ear is concerned, presents most striking and interesting features. On removing the scalp with the auricle attached, which is situated on a higher level than in the adult, the tympanic membrane will at once be revealed almost flush with the surface attached to the horse-shoe shaped tympanic ring. Instead of approaching the vertical, as in the adult, it will be found to be much more horizontal (Fig. 9). It is practically at full development, its present size, like the ossicles, being approximately that of an adult's. From the bony portion of the anterior and posterior limbs of the tympanic ring are seen small, tooth-like projections, which eventually grow outwards into the fibrous plate which connects them with the cartilage of the meatus, and coalescing, form the greater part of the osseous meatus. So that at birth there is strictly speaking no osseous meatus, and only a very short and distorted cartilaginous one.

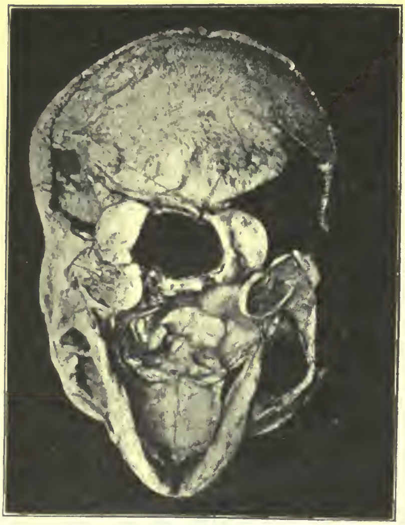

Fig. 9.—Skull of a child at birth showing the annulus tympanicus and the almost horizontal position of the membrana tympani.

The cartilage of the auricle and meatus is separated into two or three pieces by fibrous tissue constituting the fissures of Santorini.

The separate elements of the temporal bone are easily seen, especially the tympanic (Fig. 10); there are no visible indications whatever from the surface of any rudimentary mastoid cells, yet the antrum, although small, is already well developed, and may be found underneath the lower end of the squamous plate as part of the large antro-tympanic cavity. This is sometimes connected with a small, outlying, pneumatic space, which is well marked at the twelfth month. Behind

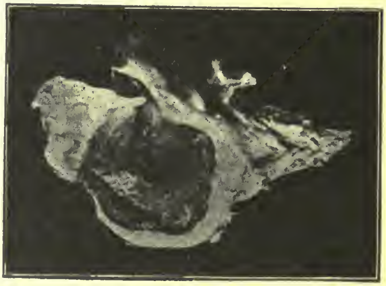

Fig. 10.—Annulus tympanicus and insertion of membrana tympani (the perforation in the membrane is of accidental origin).

the ring is a well-marked fissure, the squamo-petrosal, which, passing through the antrum, marks superficially the anterior limit of the sigmoid sinus. In or near it is the petrosquamosal sinus, a vestige of the cardinal vein which connects the lateral sinus with the external jugular vein.

Turning to the base of the dissected skull, the opening of the facial canal or stylo-mastoid foramen is conspicuous, and, relatively, very superficial, while the aqueductus cochleae, which connects the perilymph with the inferior petrosal sinus and deep lymphatics, is easily seen. On removing the tympanic membrane and the ossicles (which are almost as large as in the adult) a strikingly spacious chamber is seen ascending beneath the squamous bone, namely, the recessus epitympanicus and antrum.

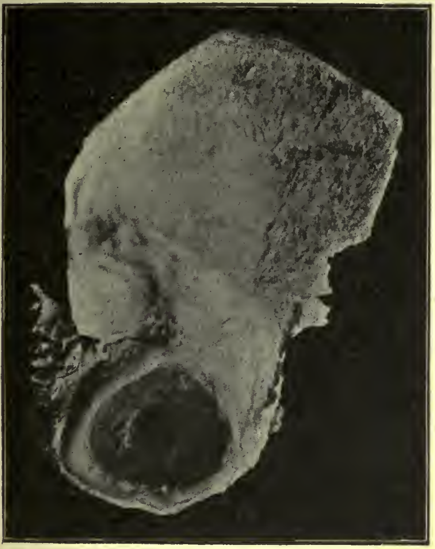

Fig. 11.—Squamo-tympanic bone of child aged 1 year, viewed from the outside, showing annulus tympanicus and outer aspect of the membrana tympani (the perforation of the membrane is of accidental origin).

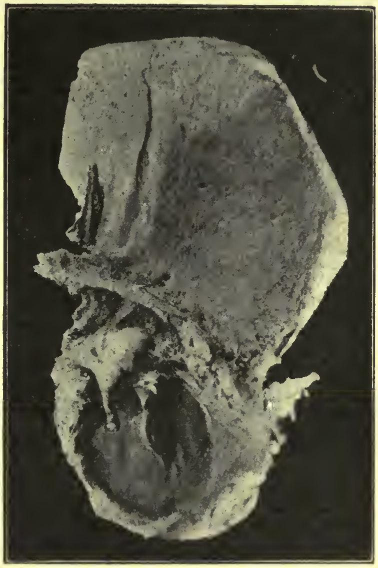

Fig. 12.—Squamo-tympanic bone of child aged 1 year, viewed from within, showing annulus tympanicus, inner surface of membrana tympani, malleus, and incus.

The oval window is also relatively well developed, while the round window is smaller but more easily seen than in later life. Just below this window a prominence is often found, the upper end of the styloid process; while farther forwards is a large opening, well marked in a dry specimen, the *ostium tympanicum* of the Eustachian tube, a most striking feature. The tube is very short and practically horizontal; it has, relatively and actually, a very large lumen, and opens into the pharynx but a short distance from the mouth. Below the floor, separated by a very thin plate of bone (sometimes wanting), is the jugular bulb.

Turning to the interior of the skull, just above the internal auditory meatus and behind the superior petrosal sinus, is a well-marked depression, the *hiatus subarcuatus* or floccular fossa, which leads to the *aqueductus vestibuli* and vestibule of the labyrinth. This carries the *ductus endolymphaticus*, which terminates under the dura mater, and is one of the most important channels of infection between the ear and the cranial cavity.

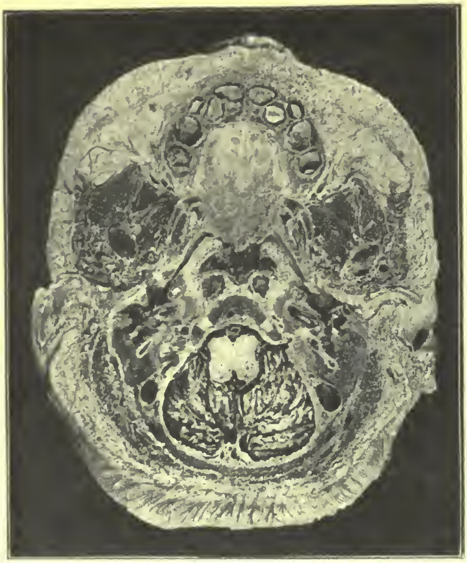

FIG. 13.—Section of the head of a child at birth at the level of the middle ear to show the continuity of the Eustachian tube, the tympanum, and the mastoid antrum (Prof. Thompson).

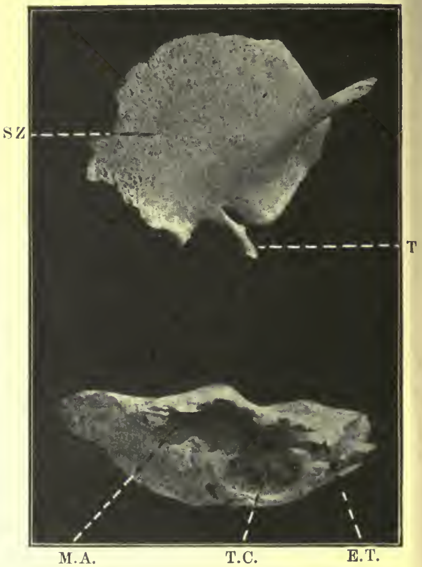

FIG. 14. — Right temporal bone at birth. The squamo-zygomatic element has been separated, and the inner wall of the middle ear exposed, showing the several cavities of the middle ear. S.Z., Squamo-zygomatic portion of temporal bone; T., tympanic element of temporal bone; M.A., mastoid antrum; T.C., tympanic cavity; E.T., Eustachian tube.

Thus the most striking feature of the early auditory apparatus is its free communication with the digestive canal and with the interior of the cranium, communications which persist, to a greater or less extent, during the whole of life.

Note.—The complete anatomy of the different regions will be considered in connection with their respective diseases.

CHAPTER III

PHYSIOLOGY OF THE AUDITORY APPARATUS

SOUND waves are conducted to the brain by the ear as light vibrations are by the eye, each organ having its adjusting or accommodation mechanism, while both are intimately correlated.

Although the exact rôle played by each successive portion of the auditory apparatus may not be fully established, the course or route of sound waves may thus be briefly summarised.

Sound waves are first collected or partially directed by the auricle and conducted by the meatus to the tympanic membrane, which, helped by the ossicles, transmits them to another membrane in the oval window on which the stapes rests. Here they enter a fluid medium, the perilymph, which, although enclosed in a rigid osseous chamber, is moved towards an elastic barrier closing the round window. By this means the to and fro vibrations are transmitted to the endolymph of the enclosed cochlear canal.

In this canal, containing the auditory epithelium, sound waves are picked up by certain hair cells and converted into nerve vibrations, which are in turn conveyed by the acoustic nerve to the sensorium.

Thus we have a sound collecting, transmitting, receiving, and perceiving apparatus.

But the whole of this is not absolutely essential to the perception of sound, since portions such as membrane and ossicles may be absent, yet hearing persists by what is known as bone conduction.

Auricle.—Many rôles have been attributed to the auricle, even so far as to accept it as an indicator of emotion and individual character or temperament. Although in man its movements are very limited, in the lower animals it has a fairly wide range of mobility. Compensation for its relatively fixed state is, however, found in the greater extent and refinement of the modelling of its surface inequalities, so that it is capable of reflecting sound waves striking it at a great variety of angles.

That it has some influence on the acuity of hearing may be proved by obliterating its various depressions with modelling clay and by comparative tests after its accidental removal and its supplemented adjustment by the hand in the case of those partially deaf. Its size and the angle at which it is placed in relation to the head seems to be of secondary importance to the refinement in its contour, for in addition to those uses already mentioned, the auricle possesses a distinct influence upon the perception of sound direction. That this is the case may readily be demonstrated by obliterating its fossae with clay, and making due allowance for variations in intensity of sounds.

The writer was able to verify these observations on a patient who had entirely lost one auricle without any loss of hearing power, and with the retention of a patent meatus. With the opposite ear plugged and while securely blindfolded, he was quite unable to localise the source or fix the direction of sound, whether proceeding from above, below, in front, or behind. From right or left he could distinguish direction, and testing the sound ear gave normal responses both as regards pitch and direction.[1]

Neither variations in size, shape, or direction of the meatus seem to influence acuity in hearing by air conduction, unless its lumen is greatly diminished.

This is well illustrated in cases of exostoses and meatal growths, for the lumen may be obstructed to a considerable degree before hearing is appreciably influenced.

By its great sensibility, especially at its inner third, it with the membrane acts as a sentinel, affording rapid and ample warning of the presence of any foreign substance.

Although the *tympanic membrane* is not absolutely essential to the sensation of hearing, it plays many most important rôles, both directly and indirectly.

Apart from its acoustic value, it has a passive use in furnishing a velum or protector to the sensitive membrane of the antro-tympanic cavity, to the delicate mechanism of accommodation, and also to the membranous apertures of the labyrinth by excluding all air-borne matter, such as dust, bacteria, and irritant gases. It also guards against sudden variations in atmospheric temperature and moisture.

The tympanic membrane is one of the driest organs in the body. Its external surface in health is optically free from secretion, yet has a somewhat greasy appearance, probably due to the adjacent ceruminous glands of the meatus, or to the natural lipolytic changes in its surface epithelial cells, for if minutely sprayed with water the drops do not adhere, but roll off as from a greasy surface.

Its inner or tympanic aspect is, however, entirely different, being distinctly moist, which is not surprising as it forms one boundary of a space in which the vapour tension must be higher than that of the atmosphere. Although moist it cannot be called wet, *i.e.* bathed by liquid, such as mucus which appreciably adheres to it. Were that so its acoustic properties would be impaired. Its moisture is maintained by water or vapour derived by osmosis and evaporation from the highly vascular mucoperiosteum rather than from a bath of mucous secretion poured out from glands. Mucous glands are rare in this cavity, they being few in number and almost entirely confined to the region of the Eustachian ostium.

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[1] It is stated that the direction of musical sounds is less accurately appreciated than that of voices (M. Foster, *Physiology*, pt. iv. 1882). This the writer has confirmed.

Therefore, although the inner surface of the tympanic membrane is moist, there is no reason to assume that it is constantly exposed to a flow of secretion like the mucous membrane of the nose or larynx.

Normal tympanic membranes removed at necropsies three to twelve hours after death have proved to be almost as dry on their inner as on their outer surfaces.

Note.—The importance of maintaining the normal high tension of aqueous vapour is well shown in the production of cholesteatomata, since dryness of the air induces metaplasia of epithelial cells, columnar being converted into squamous whenever a perforation is so sufficiently large and persistent as to upset the balance by reducing the aqueous tension to that of the meatus through a too large and too prolonged admission of air and its impurities.

Movements of Ossicles.—The ossicles transmit the vibrations of the tympanic membrane, not as a series of percussions, as their names would suggest, but by moving *en masse.*

The malleus follows all the movements of the membrane, so that when the latter moves inwards there is a coincidental displacement of both incus and stapes, but the extent of this excursion gets shorter at the labyrinthine end. The malleus does not strike the incus, for its head slightly recedes, allowing the notch to press closely against the tooth of the incus. The *os orbiculare*, in turn, closely engages the head of the stapes, which is pressed upwards and inwards, the upper margin of its base moving more than its lower. This action, by compressing the perilymph, causes a corresponding bulging of Scarpa's membrane, since the fluid is enclosed in a chamber whose walls are unyielding except at the windows.

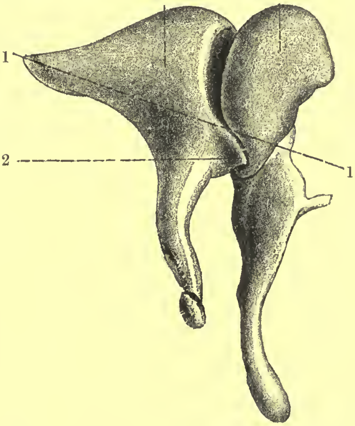

FIG. 15.—Shows the interlocking of the malleus and incus. (1) axis of rotation, (2) tooth of incus.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

As the membrane and ossicles return by their own elasticity, the intra-labyrinthine pressure becomes lessened. Should the intra-tympanic pressure become positive, the incus need not follow the malleus and membrane as they move outwards. This is an important arrangement, since the stapes and labyrinth are but slightly influenced.

In cases of deaf mutism the tensor tympani has shown considerable atrophy, doubtless owing to non-use.

The ossicular excursions are controlled by means of two muscles, thus affording an adjusting or accommodating mechanism.

The *tensor tympani* acts directly upon the malleus, pulling it with the tympanic membrane directly inwards and increasing the labyrinthine pressure through the rest of the ossicular chain. It checks the outward movement of the tympanic membrane, and probably aids the perception of loud tones.

Under ordinary circumstances it contracts reflexly through the acoustic nerve. Direct control by the will is doubtful.

When paralysed, there is reduced appreciation of high notes together with confusion of mixed sounds suggestive of disturbance in the power of accommodation.

The *stapedius* on contraction pulls the short anterior crus and the forepart of the footplate *outwards, i.e.* towards the tympanum, thereby reducing the intra-labyrinthine pressure. Consequently it controls the inward movement of the stapes and may also serve indirectly to relax the tympanic membrane.

When paralysed there is increased sensibility to all tones, especially low notes (*oxyakoia Willisii*).

Both muscles, therefore, exercise a restraining or checking influence on the movements of the membrane, ossicles, and one another in the interests of the labyrinthine pressure.

Having traced sound vibrations to the internal ear, the question now arises, how do they give rise to auditory impressions?

Although a wide range of histological study, both human and comparative, likewise careful clinical and pathological observations together with animal experiments, have been carried out, the conclusions and theories so far fail to satisfy either the physician, the physiologist, or the physicist.

It may be fairly assumed that the structures most essential to hearing are contained in the cochlear organ, and that those of the vestibule and semicircular canals, however closely responsible for equilibration, are only remotely connected with the perception of sound.

Briefly, there are two schools, one teaching that the whole acoustic apparatus simply picks up all sounds as by a telephone and transmits them to the sensorium for analysis; the other, that the cochlear apparatus actually analyses the whole range of vibrations, and that it selects, sorts, and converts them into nerve vibrations which are transmitted by the auditory nerve to the sensorium for perception.

The structures which appear chiefly responsible for the reception of vibrations by the cochlear organ are the hair cells, which are closely connected with the terminals of the cochlear nerve. To the fibres of the basilar membrane has also been attributed a large share of that function, but anatomical evidence and physical conditions afford no support to this view.

Ewald has shown (in the pigeon) that sound can be appreciated by the sensorium even after destruction of the labyrinth and the tympanic apparatus on both sides, but not after destruction of the auditory nerve.[1]

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[1] *Berlin. klin. Woch.*, 1890.

Considerable interest centres in the membrane of Corti, *membrana tectoria*, or hair band, since Ayers pointed out its intimate connection with the hair cells. He described it as an actual continuation of the cilia which had become detached and apparently formed a separate structure.[1] The arrangement of such filaments he considers as meeting the physical requirements of acoustics.[2]

That the hair cells are the principal instruments concerned is now generally accepted, but there is considerable divergence of opinion as to how that function is effected.

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[1] Ayers, *Journal of Morphol.*

[2] Retzius noticed that the cilia of the hair cells either projected into this hair band or were in contact with it, observations which support Ayers' view.

CHAPTER IV

THE CAUSATION OF DISEASES OF THE EAR

Morbid affections of the ear may arise at any period of life, although, speaking generally, they are more commonly met with in youth and early adult life than in middle life or old age. Certain types of disease are more prone to attack the ear in childhood and early adolescence, *e.g.* the exudative and suppurative types of otitis media, while adhesive and sclerotic processes are more commonly met with in middle age. Senile changes affecting both the middle and internal ear are common in those over sixty years of age. The various agencies or morbid affections which give rise to diseases of the ear may attack the organ from without by way of the external auditory meatus; from within by way of the nasopharynx, Eustachian tube, and interior of the skull, or through the circulation by way of vascular or lymph streams. The channel along which morbid processes most frequently reach the ear is the Eustachian tube, more especially so in early life, when it occupies a more horizontal position than in the adult, and is also relatively shorter, straighter, and wider. At this period of life it is also more in relation with the digestive canal, and is consequently more liable to contaminating influences.

Affections which reach the ear by way of the auditory meatus are due to such influences as exposure to cold or heat; the entrance of cold water, as in bathing, diving, etc.; injuries, direct or indirect; the entrance of foreign bodies; intermittent loud noises, such as explosions; or continuous loud noises, such as many workmen are exposed to in boilermakers' shops, riveting, etc.

Prolonged exposure to cold, partly by depressing general vitality and partly by its local action, induces a vasomotor paresis, ending at times in an attack of acute inflammation. Bathers, especially surf bathers, are liable to attacks of acute myringitis (p. 167) from the sudden impact of cold water under pressure upon the membrana tympani. Divers likewise frequently suffer from inflammatory affections of the membrane or from the presence of hyperostosis of the meatus.

Injury is also frequently done to the ear as the result of the entrance of a foreign body, and more especially from the crude methods so often adopted in its extraction. The inflammation thus set up is frequently followed by permanent damage to the membrana tympani and to the structures of the middle ear.

Scalds, burns, and the entrance of molten metal into the meatus are also prone to lead to extensive destruction of tissue, followed by cicatricial stenosis.

Injury to the head from falls or blows, boxing the ear, pulling the ear violently upwards or away from the side of the head, are also causes of occasional rupture of the membrane, with or without the production of subsequent suppurative otitis media.

Sudden explosions, as from the firing of a gun or from the discharge of heavy artillery, cause, in some cases, rupture of the membrane, in others, concussion of the internal ear. Injury to the membrane in such instances is more prone to take place when it has been weakened by previous disease, and when the explosion is quite sudden and takes the individual unawares; in other words, before he has time to accommodate his membrane.

Caisson-workers, balloonists, aeronauts, and mountaineers, from the altered circulatory phenomena which take place from condensation or rarefaction of the surrounding atmosphere, are subject to sero-sanguineous exudation or actual haemorrhage into the middle or internal ears, followed at times by permanent organic changes.

A very frequent and prolific source of morbid affections of the tubo-tympanic axis is disease of the nasal and nasopharyngeal mucosa, *e.g.* rhinitis, nasopharyngitis acute or chronic, post-nasal adenoids, and septic affections of the nasal accessory sinuses. Measles, scarlet fever, and diphtheria have frequently a most injurious influence upon the ear, the inflammatory process, often exceedingly violent, spreading up the Eustachian tube, and ending in destruction of part or the whole of the contents of the tympanic cavity. A combination of scarlet fever and diphtheria is peculiarly destructive (p. 301).

Other catarrhal affections of the respiratory tract, *e.g.* laryngitis, bronchitis, pneumonia, whooping-cough, are also prone to be followed by involvement of the ear as the result either of direct continuity of tissue or from secondary microbic invasion. The injudicious or unskilful use of the nasal douche, Politzer's bag, or nasal instruments is also at times followed by reactive phenomena.

Certain inflammatory intracranial lesions are also responsible for extension of disease to the internal ear, *e.g.* meningitis, post-basic meningitis, and cerebro-spinal meningitis, leading frequently in the young to deaf-mutism.

Vascular lesions, such as hyperaemia, anaemia, chlorosis, leukaemia, atheroma, haemorrhage, thrombosis, or aneurism, by interfering with the arterial circulation of the part give rise to extensive degenerative changes.

Interference with the venous return from the internal or middle ear leads at times to passive congestion frequently followed by exudation. Injury to the head from blows, falls, etc., accompanied at times by fracture of the base, lead to partial or complete destruction of hearing. Concussion from loud noises, explosions, and detonations are also prone to seriously injure the terminal filaments of the auditory nerve, with or without rupture of the membrana tympani.

Tubercle, syphilis, rheumatism, gout, renal or cardiac disease, diabetes, influenza, mumps, typhoid or typhus fever, frequently involve the middle or internal ear, or both cavities at one and the same time.

Such nerve lesions as tabes dorsalis, cerebello-pontine tumours, disseminated sclerosis, and general paralysis of the insane, by inducing degenerative or pressure changes in the nuclei or course of the auditory nerve, seriously implicate the perceptive portions of the auditory apparatus.

The administration of such drugs as quinine, salicylic acid, salicin, or opium, is frequently followed by troublesome tinnitus and deafness, which in the case of quinine is often permanent. The existence of previous disease often aggravates the injury done, while in exceptional cases large doses of the drug may be given with impunity where small doses disagree.

Vasomotor influences at times affect the ear, as is seen during the climacteric, pregnancy, lactation, as the result of sexual excess, and over-indulgence in food, alcohol, and tobacco.

Various reflex causes also affect the ear giving rise to otalgia, such as teething, the impulse passing from the dental branches of the fifth nerve through the otic and Meckel's ganglia, or from ulcerative processes affecting the pharyngo-laryngeal orifice.

In addition to the various exciting causes detailed above, certain predisposing causes, such as heredity and occupation, play an important rôle.

In cases of chronic catarrh and in oto-sclerosis there is frequently a history of a similar affection in one or other parent or grandparent. In all probability what is transmitted is not the disease itself, but the tendency to catarrh which induces the disease.

Certain occupations predispose to various forms of catarrhal deafness, others induce changes in the terminal filaments of the auditory nerve, while in yet others both middle and internal ears are affected.

Those who are exposed to extremes of heat and cold, to working in a dust-laden atmosphere or an atmosphere charged with irritating chemical impurities, are liable to suffer from nasal and naso-pharyngeal catarrh, with extension along the tubo-tympanic axis. Engine-drivers, stokers, and steam-lorrymen are prone to suffer from a mixed form of deafness—middle and internal ear disease—partly from variations of heat and cold and partly from constant vibration. Boiler-makers, rivetters, weavers, railway employees, etc., frequently suffer from auditory degeneration, the result of constant over-stimulation of the auditory nerves and blood vessels, ending in degeneration and atrophy.

In such cases little or nothing can be done by way of treatment beyond advising the wearing of wool or of an obturator in the ears to lessen concussion, or the sucking of a toothpick or piece of rubber so as to equalise pressure upon the two sides of the membrana tympani.

In rapidly progressive cases change of occupation is, if possible, advisable. In catarrhal cases the remedies mentioned (p. 192) may be tried, but so long as the individual remains amidst the same surroundings there can be little prospect of any improvement.

The continuous use of the telephone produces in certain operators symptoms of nervous irritability and of local disturbance in the ear, such as deafness, tinnitus, and a feeling of fulness or pressure. In addition, the constant irritation of the "head telephone" and its ear-piece is prone to induce recurring attacks of furunculosis or acne. In exceptional cases hyperaesthesia acustica is developed. Permanent damage to the hearing power is, however, quite exceptional.

CHAPTER V

EXAMINATION OF THE EAR, NOSE, NASO-PHARYNX, AND PHARYNX

When a patient suffering from some morbid affection of the ear presents himself for examination it is advisable to adopt a routine method of interrogation and examination. In many cases it is peculiarly difficult to obtain an exact history of the cause and onset of the ailment, from the fact that many morbid lesions of the ear begin insidiously and run a slow and painless course, and also from the fact that patients at times purposely suppress information about the previous existence of a discharge or of attacks of pain.

On the other hand, should the affection result from one or other of the exanthemata, or from some definite and acute illness, a concise history is, as a rule, obtainable. Many patients suffering from disease of the ear date the origin of their trouble to the time when a marked degree of deafness, pain, or tinnitus supervened, ignoring the fact that the morbid lesion had started perhaps years before, but had caused so little inconvenience as to pass unnoticed. Patients are also frequently met with who, although quite cognisant of their deafness, are unwilling to admit it.

As many of the diseases which give rise to ear complications are more common in childhood and early adult life, it will be found that a large proportion of acute ear affections occur in young people, the details of which are more or less forgotten in later life when the patient seeks advice for some morbid condition which has actually been in existence for years.

In interrogating the patient it is advisable to ascertain—

1. The actual duration of the disease.
2. The history of any previous attacks of ear trouble.
3. The cause, so far as it is known to the patient.
4. The main symptoms, such as the degree of deafness, the presence and situation of pain, the presence of tinnitus or vertigo, the existence of a discharge, and, if present, whether it is slight in amount or copious, continuous or intermittent, fœtid or non-fœtid, or blood-stained. A record of the replies to the various questions put should be kept and filed for future reference.

Objective Examination.—An objective examination of the ear should be carried out in a similarly systematic manner, the existing amount of hearing being first ascertained, followed by an examination of the external ear and external auditory meatus, the membrana tympani, and the middle ear as ascertained by inflation with the air douche or Eustachian catheter.

The state of the internal ear has finally to be investigated by the use of various tuning-fork tests, Galton's whistle, or the Edelmann-Galton pfeiffe, rotation and caloric tests.

As a very large number of affections of the ear owe their origin to morbid conditions of the nasal or nasopharyngeal mucosa, no examination of the ear is complete without a thorough inspection of the nasal chambers by anterior rhinoscopy, and of the nasopharynx by posterior rhinoscopy.

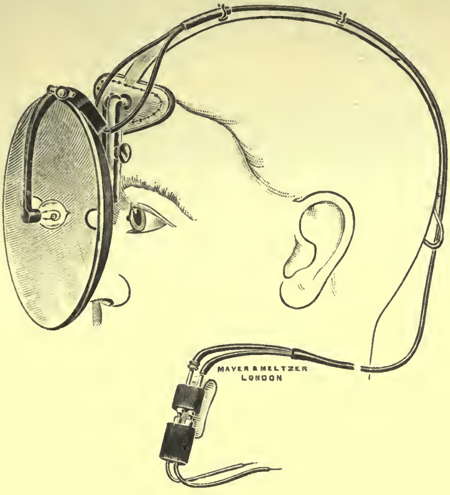

Fig. 16.—Clar's photophore.

Source of Light.—In the examination of the ear a good light is essential. Sunlight or light reflected from a white cloud or white wall answers admirably. As a rule, however, artificial light has to be employed, and the whiter the light the more natural the appearance of both normal and morbid structures. Suitable light may be obtained from a good oil lamp with a duplex prism, an Auer's gas lamp (Welsbach), Baber's spirit lamp, an acetylene lamp, an incandescent electric lamp with a "focus" filament, a Nernst lamp, or from a limelight apparatus with suitable lens.

If an electric light be selected the lamp should be of at least 32 or 50 candle-power, and the filament a "focus" filament, the ordinary looped filament giving too diffuse a light.

For operative work the oxyhydrogen limelight is admirable, the light coming as it does from a point and yielding practically parallel rays.

The lamp may be attached to an ordinary Mackenzie rack-bracket or to a vertical pedestal.

Trouvé's photophore or Clar's forehead electric lamp (Fig. 16), with storage battery or accumulator, is also useful, especially for carrying from place to place, or a small electric lamp of from 10 - 12 volts may be attached to the ordinary forehead-mirror.

Reflecting Mirror.—The reflecting mirror for the examination of the ear should be circular, slightly concave, and have a diameter of from $2\frac{1}{2}$ to 3 inches, perforated in its centre, and with a focal distance of from 4 to 6 inches. It may be used as a hand-mirror (Fig. 17), or preferably as a forehead-mirror mounted upon a forehead-band with nose-pads, and provided with a ball and socket joint. Or it may be attached to a metallic head-spring or spectacle frame. For most purposes it is preferable to use one or other form of forehead-mirror in order to leave both hands free, the one for holding the auricle and speculum in position, the other for manipulating instruments.

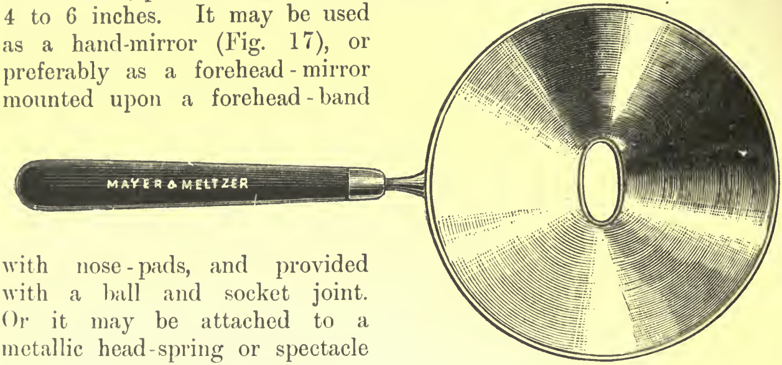

Fig. 17.—Gardiner Browne's reflector.

Aural Specula.—The aural speculum (Figs. 18 and 19) is a funnel-shaped tube about $1\frac{1}{2}$ inches long, and made of silver, white metal, vulcanite, or glass. In general, metal specula are the most serviceable on account of the ease with which they can be sterilised.

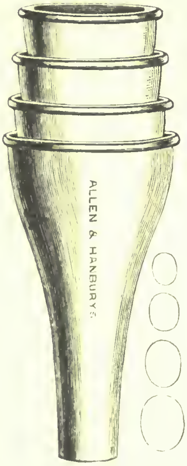

Fig. 18. Gruber's specula.

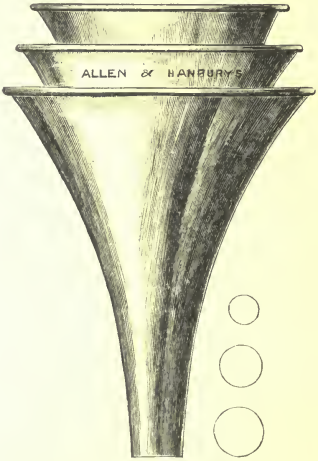

Fig. 19.—Pritchard's aural specula.

Specula are, as a rule, made in nests of three or four to meet the requirements of various-sized meatuses, and have either oval (Gruber) or circular (Politzer) ends. It is advisable to have the inner surfaces of specula dulled.

Magnifying Specula.—To obtain an enlarged image of the membrana tympani or interior of the tympanum, use may be made of a magnifying speculum (Dundas Grant) (Fig. 20).

Or the image may be magnified by having a suitable lens upon a movable bracket attached behind the circular opening in the centre of the ordinary hand or forehead-mirror (Fig. 21).

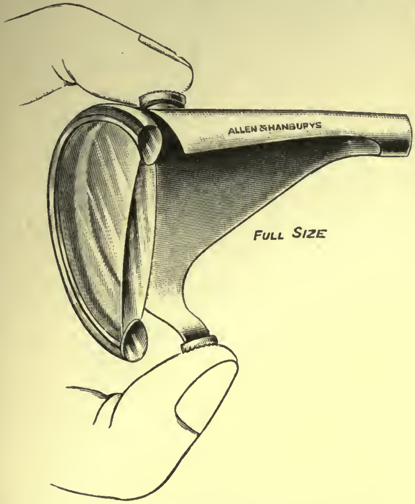

FIG. 20.—Dundas Grant's magnifying aural speculum.

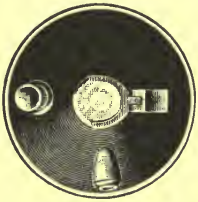

FIG. 21.—Mirror with lens.

Method of using Speculum and Mirror. — The examiner having placed the forehead-mirror upon his head in such a way that its central opening is opposite the pupil of his right eye, reflects the light upon the patient's auricle, and examines the configuration, etc., of the external ear. The speculum, previously warmed, is now held between the thumb and forefinger of the right hand and introduced into the meatus, the auricle being meanwhile drawn and held upwards and backwards between the index and third finger of the left hand (Fig. 22). While retained between the thumb and forefinger of the left hand its milled head is capable of being rotated as required. Light is then reflected from the forehead-mirror along the speculum so as to illuminate the interior of the meatus and the membrana tympani.

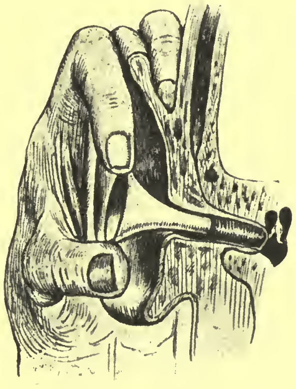

FIG. 22.—Aural speculum *in situ.*

Siegle's Pneumatic Speculum (*Deutsche Klinik*, 1864) consists of a vulcanite or metal speculum attached to a cylinder, which is divided by a glass plate set at an angle of 45° to its wall. A small hollow peg is inserted upon the side of the cylinder between the attachment of the glass plate or lens and its distal end. A rubber tube with mouth-piece or hand-bag attached is fixed over the peg (Fig. 23). The end of the speculum, covered with a thin piece of rubber tubing, is inserted into the meatus so as to hermetically close it. If now the air within the cylinder is compressed by squeezing the bellows, the membrane will be pushed inwards towards the *pars promontoria*. Conversely, if the air within the cylinder be rarefied the membrane and, with it, the ossicular chain will be drawn outwards.

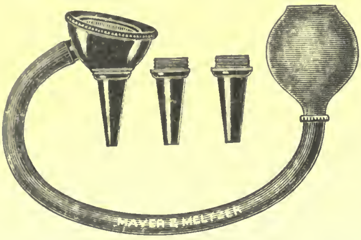

Fig. 23.—Siegle's pneumatic speculum.

By alternately compressing and rarefying the air within the meatus a to and fro motion is produced, which serves as a means of massaging the ossicular chain, demonstrating the mobility of the membrane, the laxity or otherwise of cicatrices, the presence of a minute perforation, and the presence of intratympanic adhesions, pus or mucus.

Ear Cough.—The introduction of a speculum, probe, or other instrument into the external auditory meatus produces at times a violent, dry, hard, and spasmodic cough which frequently lasts a few seconds even after the withdrawal of the exciting cause. The presence also in the meatus of a foreign body, inspissated cerumen, or localised inflammation of its cutaneous walls, may produce a similar cough, which may lead to the suspicion that the individual is suffering from some form of pulmonary disease.

The reflex responsible for the cough in such cases is conveyed along Arnold's nerve, a branch of the vagus, which is distributed to the skin of the posterior surface of the pinna and the inferior and posterior walls of the auditory meatus.

A proper view of the membrana tympani is at times impossible owing to the presence of flakes of epidermis, cerumen, hairs, etc., in the meatus. To get rid of such obstructions a pair of angular forceps (Fig. 24), fine spud, or curette is employed. Under efficient illumination the forceps is passed through a suitable speculum and the obstructing body gently grasped between its blades and withdrawn. To prevent hairs obstructing a view of the deeper parts of the meatus the outer surface of the speculum should be smeared with vaseline, and the speculum turned round two or three times in the meatus. By so doing the hairs are temporarily plastered to the meatal walls.

To effectually dry the deeper portions of the meatus or the surface of the membrane it is frequently necessary to employ a cotton-tipped probe. The probe (Fig. 25), bent at the ordinary aural angle, has its distal end roughened so as to admit of the cotton-wool adhering. Under illumination it is passed into the meatus.

The aural probe is also of great service in ascertaining the site of attachment of polypi, the presence of a sequestrum or carious bone, etc.

Syringing the Ear.—To syringe the ear effectively and at the same time without causing pain or inconvenience to the patient requires considerable practice. A brass or rubber syringe may be employed (Fig. 26). If the former, it should be provided with a "ledge" or "ring," so as to prevent the index and middle fingers slipping when the piston is being pushed home by the pressure of the thumb; if the latter, Wyatt Wingrave's modification of the ordinary enema syringe answers admirably, especially for auto-syringing. The nozzle of the syringe should be pointed and tapering, and should not end in a bulbous extremity. Many of the syringes upon the market are provided with conical nozzles made of bone, which so fill up the meatus as to be positively useless, if not actually harmful. A tapering nozzle made of white metal which can readily be bent is very serviceable. All syringes should have detachable nozzles.

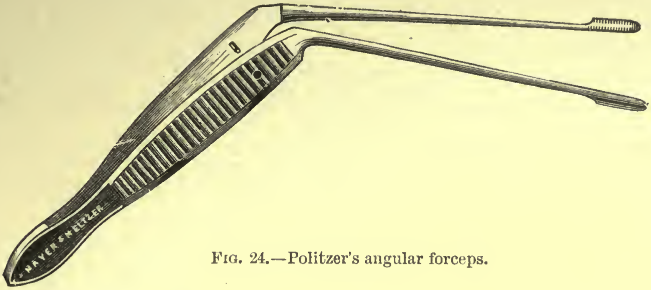

FIG. 24.—Politzer's angular forceps.

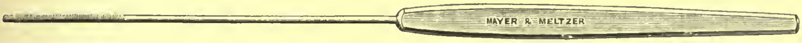

FIG. 25.—Milligan's aural probe.

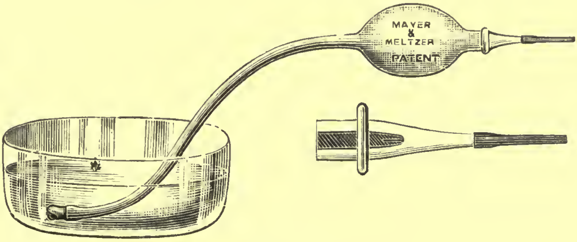

FIG. 26.—Wyatt Wingrave's syringe.

The fluid used to syringe the ear should be warm (about 100° F.). If too hot or too cold it is extremely prone to cause vertigo and at times nausea and syncope, especially in cases where the membrana tympani is perforated. A towel or thin sheet of mackintosh should be pinned round the patient's neck so as to prevent any fluid trickling down and wetting the collar or other clothing.

The receptacle for catching the fluid the ear has been syringed with may either be an ordinary soap-dish or a kidney-shaped glass or vulcanite dish. It should be held immediately under the lobule, and pressed gently but firmly against the side of the neck. To syringe the ear the surgeon grasps the auricle between the thumb and index finger of his left hand, and draws it gently upwards and backwards (in infants and young children downwards, outwards, and forwards) so as to straighten the curve of the meatus. The nozzle of the syringe is then introduced into the meatus and directed towards the occiput along its upper or posterior wall for a distance of half an inch or thereby, and the syringe slowly and evenly emptied. The head is then turned over and any fluid remaining in the meatus allowed to run out, after which it is carefully dried with a pledget of absorbent wool and packed with a strip of gauze or antiseptic wool.

When the surgeon is called upon to remove an impacted plug of cerumen or a foreign body considerable perseverance may have to be employed to attain the desired result.

Between every two or three syringefuls it is advisable to inspect the meatus with mirror and speculum to ascertain the exact state of affairs.

Various solutions may be employed, *e.g.* borax ($\frac{1}{2}$ per cent), bicarbonate of soda ($\frac{1}{2}$ per cent), or sulphate of soda (1 per cent), the two first named being especially useful as solvents of fatty matter, and the third as a solvent of globulin.

Examination of the External Auditory Meatus and Membrana Tympani.—With the mirror and speculum the external auditory meatus should be carefully inspected, special attention being directed to any deviation from the normal in its size, shape, colour, and sensibility, to the presence of discharge, granulation tissue, excess or diminution of cerumen, or to the existence of stenosis either cicatricial or resulting from the presence of exostoses or hyperostoses.

The membrana tympani presents by daylight a pearl-grey, shining, and iridescent appearance, and is stretched across the lower or deeper end of the meatus in such a way that with its postero-superior walls it forms an angle of about 120°, and with its antero-inferior an angle of about 45°. Those portions of the membrane, therefore, which are situated posteriorly and superiorly are, consequently, nearer to the observer's eye than those situated antero-inferiorly. The lower portion of the anterior segment of the membrane is of a somewhat darker grey colour than the upper portion of its posterior segment. The actual colour of the membrane varies, however, with its translucency, with the nature of the light employed to illuminate it, and with the colour of the tympanic mucosa. In infancy and youth the colour of the membrane is of a darker grey than in adult life, while in old age the membrane loses its polish and natural lustre.

The colour of its posterior segment is especially influenced by reflection from the long process of the incus and chorda tympani nerve, by the presence of v. Tröltsch's pouch, and by reflection of light from the pars promontoria.

The general inclination of the membrane is slightly concave outwardly. Its inclination and curvature are, however, modified by the size and width of the meatus and its translucency. Thus if very translucent it appears to be less concave than when somewhat opaque.

The prominent features or landmarks seen upon its surface are—

1. The short process of the malleus—processus brevis.
2. The handle of the malleus—manubrium mallei.
3. The anterior and posterior folds.
4. The light-reflex.
5. The membrana flaccida.

The short process (*processus brevis*) of the malleus appears as a pointed eminence towards the upper and anterior part of the membrane.

Running downwards and backwards from the short process to a little below the centre of the membrane is the handle of the malleus (*manubrium mallei*), which ends in a club-shaped extremity, the *umbo*. Owing to the peculiar inclination of the membrane only the posterior surface of the handle of the malleus is visible, its anterior surface being in shadow.

Running forwards and backwards from the processus brevis to the periphery of the membrane are the anterior and posterior folds respectively. These folds, only slightly prominent in the healthy state, are markedly so in certain pathological conditions.

Running downwards and forwards from the umbo is the light reflex or cone of light, which in the healthy state forms an almost equilateral triangle. When, however, the membrane is retracted and indrawn the light reflex, if still present, assumes the shape of an isosceles triangle, while, on the other hand, if the membrane be bulged outwards as the result of the presence of secretion within the tympanum, it is either entirely lost or broken up into segments. The light reflex is an optical phenomenon, and is due to the incidence of rays of light falling upon a membrane inclined in a particular way. According to Trautmann, the fact that the light reflex is triangular is due to the funnel-shaped inward curvature of the membrane. Alteration in its size and shape are, however, of comparatively slight diagnostic importance.

The portion of the membrane above the short process of the malleus and anterior and posterior folds is known as Shrapnell's membrane or the *membrana flaccida*, from the fact that it consists of only a dermic and mucous membrane layer, the substantia propria or middle layer being practically non-existent. In conjunction with the osseous attic wall it forms the outer boundary of the epitympanum or "attic" of the middle ear.

In cases where the membrana tympani is peculiarly translucent it is possible at times to see the long process of the incus running downwards and parallel to the manubrium mallei, and occasionally also the incudo-stapedial articulation, the tendon of the stapedius muscle, and the posterior crus of the stapes.

In addition, a dark recess in the lower and posterior part of the tympanum, the *fossula rotunda*, is occasionally to be noted.

Clinical Divisions of the Membrana Tympani.—For clinical purposes the membrane is divided into two segments, an anterior and a posterior, by an imaginary vertical line running through the handle and short process of the malleus. A subdivision is effected by another imaginary line drawn horizontally across it at the level of the umbo (Fig. 27). Hence four unequal quadrants or segments are formed, antero-superior and antero-inferior, postero-superior and postero-inferior.

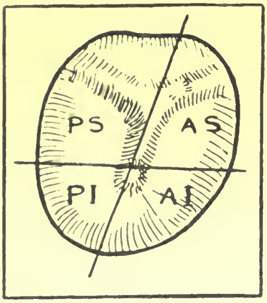

FIG. 27.—The clinical divisions of the membrana tympani. PS, posterior superior segment; PI, posterior inferior segment; AS, anterior superior segment; AI, anterior inferior segment.

Tests for and the Estimation of the Hearing Power. — *The Range of Hearing.*— The normal range of hearing, from 16 to 48,000 vibrations per second, by a healthy individual with healthy ears varies with his age. In youth the upper limit is about 20,000 vibrations per second, in middle age about 37,000 vibrations per second, while in old age it varies from 12,000 to 14,000 vibrations per second.

In practice it is well to remember these variations in order to make due allowance when testing patients afflicted with one or other form of middle or internal ear disease.

The capacity possessed by an individual of hearing simple tones may be estimated by the use of (1) the acoumeter (Politzer), (2) whispered and spoken speech, (3) the watch, (4) tuning-forks, (5) Galton's whistle or the Edelmann-Galton pfeiffe, and (6) König's rods.

Testing with the Acoumeter.—The acoumeter (Fig. 28) consists of a vulcanite pillar a little over an inch in length, to the ends of which are fixed finger-rests. Attached at right angles to the vulcanite pillar is a fixed steel rod an inch in length and also a movable arm $1\frac{1}{2}$ inches long, terminating in a rounded end, which serves as a percussion hammer, and a shorter arm which, when pressed upon, serves to raise the hammer.

The method of using the acoumeter is as follows. The instrument is held between the index finger and the thumb of the examiner. By pressure with the middle finger upon the short arm of the lever, the long arm is raised to a given height. By relaxing the pressure the long arm is allowed to fall and strike the steel cylinder, with the result that a uniform volume of sound or click, capable of being heard by a normal ear at a distance of about 40 feet, is given off. The acoumeter is

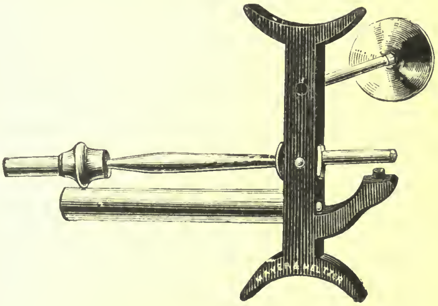

FIG. 28.—Politzer's acoumeter.

especially of service when testing the hearing power of persons incapable of hearing the tick of a watch.

When it is desired to test the conduction of sound through the bones of the head a metal pin 4 centimetres long and terminating in a metal disc is attached to the instrument. By pressing the metal plate upon the forehead or mastoid process the perception of sound through the cranial bones may be estimated.

The great advantage of the acoumeter is that the click is a sound of uniform intensity.

The Speech Test.—The fact that the normal human ear possesses a greater range of hearing power than is actually required for the purposes of ordinary social intercourse is the reason why individuals suffering from slight degrees of deafness still retain sufficient hearing power for general purposes. The existing deficiency is, however, at once noticed if the speaker be at some distance, as in church, in the lecture-room, etc.

A very fair and accurate estimate of a person's hearing capacity may be made by the use of the ordinary speaking voice. When testing with the voice the patient should sit or stand with the ear to be examined directed towards the speaker, the opposite ear being firmly closed by pressure upon the tragus, or by inserting the finger, previously moistened, into the auditory meatus. The patient's eyes should at the same time be kept closed. If the examiner's ordinary voice be heard at a distance of more than 15 feet, the whispered voice should be employed. Whispered speech (normally heard at an average of 25 yards) has the advantage of greater uniformity, while in addition the disparity between vowels and consonants is not so marked. When testing the examiner should gradually approach the patient, whispering selected words or numbers until they are clearly heard. According to Bezold it is advisable to whisper with the residual air after expiration. When testing both ears different words or numbers should be used, as if once heard the patient anxious to hear is prone to guess. Words containing a number of vowels are more easily heard than those largely composed of consonants. It is advisable also at the different examinations of the patient to employ words containing a somewhat similar number and arrangement of vowels and consonants, and also to keep the voice as far as possible at a uniform pitch. Shrill voices are not so well heard as ordinary toned voices, especially in cases of disease of the internal ear.

According to Oscar Wolf the letter R is the lowest in the scale, having 128 vibrations per second, while the letter S is the highest, giving from 5400 to 10,840 vibrations per second. Where the room in which testing is taking place is small it may be lengthened by an ingenious plan suggested by Kahn. If the surgeon standing at one end of the room turns his back upon the patient the hearing distance is increased by one-third, and if still too small the patient by turning his affected ear to the opposite wall increases it by two-thirds.

Testing with a Watch.—In the first place, the distance at which the watch can be heard by a number of persons possessing normal hearing power must be known. The tick of any watch is always louder just after having been wound up, and fainter when it is nearly run down or has been recently oiled. It is better, although not essential, to employ a stop-watch possessing a clear metallic tick.

When testing (which should be done in a quiet room) the patient's eyes should be kept closed, the ear not being tested firmly occluded by pressing the tragus backwards, or by inserting the finger into the meatus, and the watch gradually brought nearer and nearer to the ear which is being tested. For the sake of convenience the hearing capacity of the individual may be expressed in the form of a fraction (Prout). Thus if an individual hears a watch, which by a normal ear can be heard at 60 inches, at a distance of 20 inches the fraction representing the hearing power is $\frac{20}{60}$ or one-third of the normal.

If the watch is heard only on contact with the external ear the fraction is $\frac{c}{60}$, if on pressure $\frac{p}{60}$, and if not at all $\frac{0}{60}$. The objections to the watch test are that every watch varies in both pitch and volume, that the sound is affected by climatic conditions, and by the interval which has elapsed since last wound up. Moreover, the tick of a watch is a combination of sound and noise.

S. Bryant[1] has suggested the following plan of testing with the watch: It is first approached towards the patient until its tick is heard; it is then withdrawn gradually from the ear until the patient ceases to hear it; finally, it is again brought towards the ear until heard by the patient. The various distances are noted in inches, and the percentage of the first to the last represents the actual acuity of the auditory centre.

The distance at which a watch is heard when brought gradually towards the ear is somewhat less than when the watch is withdrawn from the ear. The difference in inches is made use of by Rumbold as a means of estimating the tonicity of the muscles of the middle ear.

There is often considerable disparity between the hearing of a watch and the hearing of conversation. A patient who may be able to hear lightly spoken conversation across a room may not be able to hear the tick of a loud watch even when held close to his ear. During the progress of the case the hearing for conversation may improve, while that for the tick of a watch may even deteriorate.

It has been observed that those individuals who become deaf in the later years of their life often hear speech better than they do the tick of a watch, while those who are afflicted early on in life hear the tick of a watch better than they do conversation.

The test should be repeated several times so as to ensure as great accuracy as possible, and a record kept of the result.

The Quantitative Examination of Audition.—*Tuning-Forks.*—In the quantitative examination of audition by air conduction a series of tuning-forks is required. For practical purposes five forks, C = 128 vs., $C^1 = 256$ vs., $C^2 = 512$ vs., $C^3 = 1024$ vs., and $C^4 = 2048$, are as a rule employed (Fig. 29). In order to overcome the effect of overtones clamps are fixed to the prongs of the fork. By moving these clamps upwards and downwards a difference of at least an octave can be produced.

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[1] *Diseases of the Nose, Throat, and Ear*, 1909.

The method of employing the tuning-fork is as follows. The stem of the fork is held between the examiner's thumb and index finger, and the prongs near their lower third struck against the bent knee-cap or some hard substance (preferably covered with a piece of cloth), and with as far as possible a uniform strength of stroke. The vibrating fork is then at once placed in front of the ear, and held there until it has ceased to be heard. It is then transferred to the other ear or to the examiner's ear, and the number of seconds it is still heard is recorded.

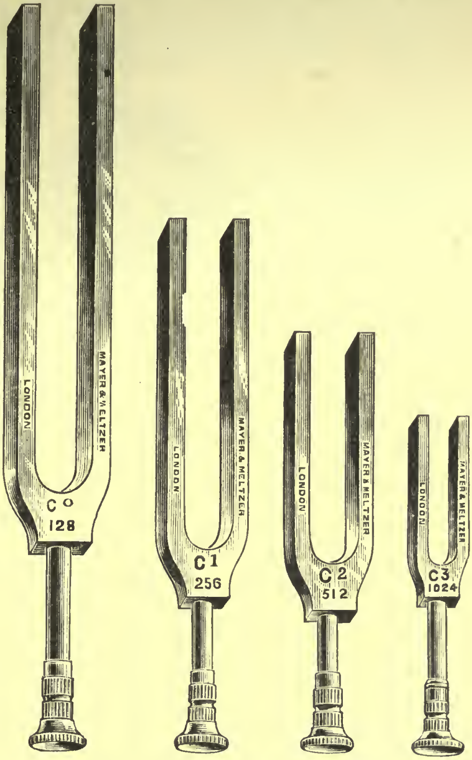

Fig. 29.—Hartmann's tuning-forks.

Tuning-forks are, however, of greater value in estimating the qualitative perception of sound; in other words, in ascertaining the power of hearing the pitch of notes. The same series of forks as used for the quantitative perception of sound is employed, and the time during which a high-pitched fork is heard compared with that during which a low-pitched fork is heard.

The results of clinical and subsequent pathological work have fairly clearly established the fact that in affections of the conducting apparatus there is defective appreciation of low tones, whereas in affections of the perceptive apparatus high tones are badly heard.

When both the upper and lower tone limits are badly heard, the perception of medium tones being good, the deduction is that both the conducting and the perceptive apparatus are at fault.

It should be borne in mind that in elderly people the perception of sound through the cranial bones is frequently diminished, and that much of the value of tuning-fork tests depends upon the intelligence of the patient and the patience of the surgeon.

Galton's Whistle.—For testing the appreciation of high tones Galton's whistle is employed. The whistle (Fig. 30) is attached to a rubber ball, and by means of a screw-piston its length, and therefore its pitch, can be altered. Its barrel is marked in millimetres and tenths of a millimetre so as to enable the point at which the patient ceases to hear the sound to be readily noted. When testing the whistle is held about a foot away from the affected ear, the sound ear being firmly stopped up. The patient should be warned to pay no attention to the blowing of the bellows, but to listen only for the whistle.

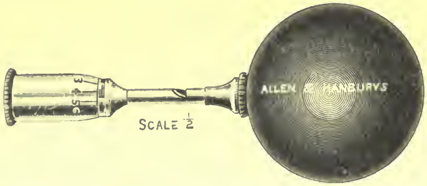

Fig. 30.—Galton's whistle.

Under normal circumstances the human ear is capable of hearing a note of 50,000 vibrations per second. When not more than 20,000 vibrations are heard there is probably some lesion of the auditory nerve present.

The capacity for hearing high-pitched sounds varies with the age of the individual. In children it is more acute than in adults, and in adults more acute than in old age.

The Edelmann-Galton pfeiffe and König's rods are only of value in testing advanced bilateral affections of hearing. In unilateral cases it is not possible, even when the sound ear is apparently quite closed, to exclude the perception of high tones.

The Galton-Edelmann Whistle.—This instrument (Fig. 31) is particularly useful in the determination of the power of perception of high tones. It is provided with a very fine bore and with a movable plug, so that the tube may be lengthened or shortened at will. When the tube is lengthened, the pitch of the note is lowered, and vice versa. It is also furnished with a small bellows from which air is blown through the tube. A millimetre scale is attached to the main stem, from which it is possible to read the distance of the piston from the lower end of the tube. A table is provided with the instrument in order to indicate the exact number of vibrations the particular note possesses.

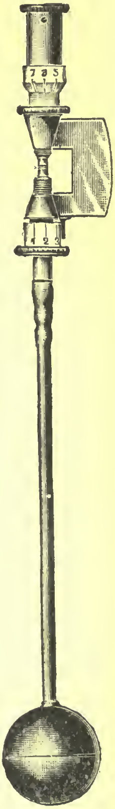

Fig. 31.
Galton-Edelmann whistle.

König's Rods consist of a series of steel cylinders of varying lengths suspended by wire threads from a horizontal bar. They are used to test the perception of the upper tone limit, and have a range of from 20,000 to 100,000 vibrations per second.

Testing with Tuning-Forks.—*Schwabach's Test.*—This test can only be applied by an examiner who himself possesses normal auditory nerves. A tuning-fork is placed upon the patient's vertex or mastoid process, and after it has ceased to be heard is transferred to the examiner's vertex or mastoid process. If heard by the examiner after it has ceased to be heard by the patient, the inference is that a lesion of the patient's perceptive media is present. In other words, diminished perception of sound through the cranial bones indicates disease of the auditory nerve.

In disease of the sound-conducting apparatus Schwabach also found that a tuning-fork placed upon the vertex is heard longer than under normal conditions. A means of differential diagnosis between diseases of the external and middle ear and diseases of the internal ear is thus afforded, as we are justified in assuming disease of the conducting media when the duration of the perception of sound through the cranial bones is lengthened (– Rinné), while when there is markedly shortened osseous perception of sound (+ Rinné), combined with marked deafness for speech, an affection of the auditory nerve may safely be diagnosed.

From a prognostic point of view Schwabach's test is also of value, as the prognosis is better in those cases in which the duration of sound through the cranial bones becomes gradually lengthened.

Weber's Test.—Weber's test depends upon the following experiment: If one ear be closed by pressure of the finger, and if a vibrating tuning-fork be placed upon the bridge of the nose or upon the middle line of the head, the sound produced is heard with the obstructed side so much so that apparently no sound at all is heard with the opposite or open ear.

The closure of the ear with the finger is comparable with the effect produced by pathological lesions of the air-conducting apparatus, the external and middle ears. Hence, in cases of obstructive disease of the external meatus or middle ear, a tuning-fork placed upon the vertex is heard best upon the deafer side, the existing pathological lesion preventing the dispersal from the ear of the waves of sound passing through the cranial bones. Consequently the waves of sound which tend to pass in all directions are, owing to the existing obstruction, reflected backwards to the auditory nerve, thus increasing the intensity of the sound of the tuning-fork.

If, on the other hand, the sound is referred to the normal or open ear, the lesion responsible for the existing deafness is situated within the internal ear, or in the course of the auditory nerve or its nuclei of origin. Where both ears are affected as the result of some lesion of the conducting media, the sound produced is referred to the deafer ear. When employing Weber's test great care should be taken as the patient tends naturally to refer the sound to his healthy ear, his mind being preoccupied with the idea that he should hear it better with his good ear.

In bilateral affections of the external or middle ear the vibrations of the tuning-fork are, as a rule, referred to the deafer ear. Such is not, however, always the case, as occasionally it happens that the tuning-fork is more distinctly heard by the better of the two ears. In cases of uncomplicated auditory nerve-deafness the tuning-fork placed upon the vertex is referred to the normal ear.

Weber's test is therefore of great value when a positive result is obtained; in other words, when the patient is able to state definitely that the sound is referred to the affected side. When, on the other hand, the sound is referred to the better or possibly normal ear, as occurs in labyrinthine affections and in certain cases of bilateral middle-ear deafness, the test is practically valueless.

Rinné's Test.—With the normal ear the length of time a vibrating tuning-fork is heard when placed opposite the auditory meatus is longer than when placed upon the mastoid process or bridge of the nose. Aerial conduction of sound is thus better than bony; in other words, with a normal ear Rinné is positive (Rinné +). In cases, however, where the conduction of sound is interfered with from a lesion of the external or middle ear (the internal ear being healthy), the duration of the aerial conduction of sound becomes less than the conduction of sound through the cranial bones. This is spoken of as negative Rinné (Rinné –).

Normally the C^1 tuning-fork (256 vibrations per second) is heard twice as long through the air as through the bones of the head. When the duration of the aerial conduction of sound is shortened, some lesion of the conducting media is present.

In uncomplicated disease of the internal ear the conduction of sound through the air is better than through the cranial bones.

To apply the test a C^1 tuning-fork is taken and struck against some hard object. The stem of the fork is then applied to the base of the mastoid process, and after the vibrations have ceased to be heard through the cranial bones, is rapidly transferred opposite the orifice of the auditory meatus. The time in seconds during which the fork is still heard is noted and compared with the normal. Conversely, when aerial conduction is shortened, the time during which the tuning-fork is still heard when placed over the mastoid process is noted. The longer these periods are the greater the accuracy of the test. When, in a case of marked deafness, bone conduction is of longer duration than aerial conduction (– R), the deduction is that the obstructive lesion is situated somewhere in the conducting mechanism, whereas, when aerial conduction is greater than bony conduction (+ R), the lesion is in the perceptive portion of the ear.

Gellé's Test.—When the air in the auditory meatus is compressed by means of a Siegle's speculum the membrana tympani, and with it the ossicular chain, is pushed inwards with the result that under normal circumstances intra-labyrinthine tension is increased. If a vibrating tuning-fork be placed upon the vertex while the air in the meatus is compressed, the tone is diminished according to the amount of pressure used (positive result). When, however, the tone is not diminished (negative result), the inference is that some form of anchylosis of the stapedio-vestibular articulation is present preventing an increase of intra-labyrinthine tension.

When the labyrinth is the seat of pathological changes, the stapedio-vestibular articulation remaining normal, the tone of the tuning-fork will be found to be diminished with every condensation of air in the meatus, just as under normal circumstances. In labyrinthine disease a marked increase of dizziness is frequently produced during the time that an increase of pressure is kept up.

Bing's Test. — Bing's test is made use of to differentiate between middle and internal ear disease.

The test is based upon the fact that when a tuning-fork placed upon the mastoid ceases to be heard, it is again heard when the auditory meatus is closed with the finger. When in a case of marked deafness the sound is not again heard on closing the meatus, the deduction is that middle-ear disease is present. On the other hand, if it is heard again, the deduction is that some form of labyrinthine disease exists.

Another test, devised by the same author, is made use of to differentiate between the presence of stapes-anchylosis and inflammatory adhesions between the malleus and incus preventing the transmission of sound waves.

If conversation through a speaking-tube attached to a Eustachian catheter *in situ* is heard better than conversation through the same tube inserted into the auditory meatus, the deduction is that the footplate of the stapes is movable, and that the malleo-incudal joint is involved, and rendered less mobile than under normal circumstances.

Notwithstanding the great amount of work which has been accomplished with the tuning-fork, and the large number of papers which have been written to show the value of this or that test, the clinician frequently finds himself face to face with results which objective examination would tend to negative. The classification of certain diseases of the ear still leaves much to be desired, and until it has been placed upon a perfectly scientific basis, various anomalous results will crop up from time to time.

For practical purposes it may be said that middle-ear disease (obstructive deafness) is characterised by—

(1) A varying loss of aerial conduction of sound.

(2) Ability to hear high-pitched sounds better than low-pitched sounds.

(3) Ability to hear better in a noise (this, however, only applies to certain types of otitis media).

(4) Improvement of audition after inflation (this is not, however, always the case).

Whereas disease of the internal ear (perceptive deafness) is characterised by—

(1) A varying loss of conduction of sound through the cranial bones.

(2) Ability to hear low-pitched sounds better than high-pitched sounds.

(3) Diminished power of hearing in a noise.

(4) Diminished power of hearing after inflation.

In uncomplicated middle-ear deafness Rinné is negative (– Rinné), the diminished number of seconds (as compared with the surgeon's healthy reaction) varying with the severity of the lesion.

In certain cases of unilateral nerve deafness a – Rinné is also met with. This is due to the effect of bone conduction to the opposite ear.

In testing it is advisable to use the forks C (128) and C_2 (512), and when a double negative Rinné is present the diagnosis of obstructive deafness is, for practical purposes, established.

Noise Apparatus for the Detection of Unilateral Deafness.—To determine the existence or otherwise of unilateral deafness Bárány has invented an apparatus consisting of a hammer worked by clockwork which strikes against a membrane, the noise from which is conducted directly to the ear by means of an ear speculum. When the speculum is introduced into the sound ear and the clockwork set in motion the noise produced is such as to exclude it from appreciating any other extraneous sound. In this way it is possible to examine the hearing capacity of the other ear. To do so it is necessary to speak with a loud voice. With a normal ear it is possible to hear conversation several yards away, and whispered conversation at at least one yard. If the ear being investigated be completely deaf no sound of any sort is perceptible. With this instrument the detection of complete unilateral deafness is rapidly established.

An International Uniform Acoumetric Formula.—The necessity of having a uniform acoumetric formula for recording the various hearing tests in general use has long been felt. At the International Otological Congress held in Buda-Pesth in 1909 the following formula was presented by a Committee consisting of Messrs. Politzer, Gradenigo, and Delsaux, and accepted by the meeting:[1]—

↗ *AD*	25	20	30	÷ 8	2,0	8,0
WS (15) + 5	a^1M (20)	a^1A (60)	c^4A (30)	*R* (35)	*H* (3,0)	*P* (15,0)
AS	20	60	30	+ 35	3,0	15,0
	15,0	3,0	D_I	40,000		
	V (38)	*v* (78)	*LI*	*LS*		
	> 20	15,0	C_2	40,000		

AD and *AS* indicate *Auris dextra* and *Auris sinistra.*

W indicates *Weber's test*, the lateralisation being shown by an arrow pointing in the appropriate direction; if there is no lateralisation the sign = (equal) is put down; if the tuning-fork is not heard at all on the vertex then a zero. For these tests the tuning-fork a^1 (435 d. v.) is employed.

S means *Schwabach's experiment*, the difference of the time as compared with the normal being expressed by means of a + or a ÷[2] with the number of seconds, or, if necessary, with an = when the duration of perception is normal.

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[1] The writers are indebted to the *Journal of Laryngology* for permission to publish Dr. Dundas Grant's translation of Dr. Jörgen Möller's transcript (*Journal of Laryngology*, December 1909).

[2] This ÷ (division) symbol is the one used in the author's MS., but is probably intended to be equivalent to our – (minus).

For this, also, the same tuning-fork, a^1 (435) is used, the normal duration of perception for the fork used being noted.

a^1M indicates the length of perception of the tuning-fork a^1 (435) on the mastoid process (M = *mastoideus*, bone-conduction). The normal duration is added, the duration of perception by the right and the left ear of the patient being indicated in seconds above and below the line respectively; if only the difference of duration greater or less than normal is measured it can be noted by means of a + or ÷, and for rapid examination without the statement of the number of seconds simply + *d. h.* (lengthened) or ÷ *d. h.* (shortened); normal duration of perception on the part of the patient is in this case indicated by =. A normal time of perception for the fork employed must be noted in cases in which the difference in duration alone is measured. Instead of the tuning-fork a^1, another, such as, for example, c^2 (512), may be used.

a^1A indicates the length of perception of the tuning-fork a^1 (435) when held directly opposite the meatus (A = *aër*, air-conduction). The other indications are exactly as given for bone-conduction.

c^4A indicates the duration of perception for the tuning-fork c^4 (2048) when this is held opposite the meatus.

R stands for *Rinné's test*, the difference between the air- and bone-conduction, or it may be between bone-conduction and air-conduction. The number of seconds is inscribed in such a way that a + is used when air-conduction and a ÷ when bone-conduction preponderates; if the duration of hearing of air- and bone-conduction is the same it is indicated by =; for superficial investigation it may be sufficient to indicate simply + or ÷ without adding the number of seconds. If the tuning-fork is only heard by air-conduction this can be indicated by + t, when only by bone-conduction by ÷ θ, whilst the amount of the difference is put down as $t \div \theta$, t being used to indicate air-conduction and θ bone-conduction. If the difference in duration in Rinné's experiment is to be fixed the normal difference of duration for the fork employed must be added in brackets. For this experiment the tuning-fork a^1 (435) is used.

H stands for *Horologium* (watch), the normal distance of audibility in metres being put in brackets, the distance for the right and left ear of the patient being marked above and below respectively. If the watch is only heard on contact with the auricle the letters *a. c.*, = *ad concham*, are put down.

P indicates *Politzer's acoumeter.* The distance is written in metres in the same way as for the watch.

V (*Vox*) indicates ordinary conversational voice, *v*, whispered voice; the distance is put down in metres and the words employed added in parentheses. If all the test-words are heard at the full distance available, then it is to be assumed that at least a few words can be heard at a greater distance; in this case the amount of the distance in metres is written down with the sign > (greater than). If the voice is only heard in the immediate neighbourhood of the ear it is put down as 0,01, *d. h.*, that is, 1 cm. If the tests are made with words of equal intensity of "isozonality," as classified by Quix,[1] those different groups are bracketed together and the value for the deepest group should come first.

LI indicates *Limes inferior*, the lower limit. It is, when possible, determined by means of Bezold's continuous tone series, and the deepest heard tone marked with its musical denomination or else with the number of double vibrations per second to which it corresponds. If the investigator has not got a continuous tone series at his disposal, but only, for example, a series of *C* forks for the different octaves, there must be added after the description of the deepest double forks the sign $<$ (less than), which indicates that perhaps still deeper tones might be heard. In these cases it must be indicated with what series of sound the investigation is made.

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[1] The Seventh International Otological Congress, held at Bordeaux, August 1 to 4, 1904 (see *Journ. of Laryngol., Rhinol. and Otol.*, October 1904, p. 532).

LS indicates *Limes superior*, the upper limit. If this is determined by means of Edelmann's Galton whistle the vibration number of the tone is marked down. In other cases the pitch of the tone is tested with the nature series of sound, such as Schulz's monochord, or König's rods, etc. ; this must be expressed in the description of the functional test ; the highest pitched tone which is heard is taken as the limit.

It is permissible under certain circumstances to omit some of the methods of examination, as any particular tests with the watch and with Politzer's acoumeter, as also Schwabach's and Rinné's tests, if the bone- and air-conductions are tested separately, as also, on the other hand, the bone- and air-conduction if Schwabach's and Rinné's tests are preferred. On the whole it is advisable, however, to employ all the tests. If any of the tuning-fork tests are made with a different fork from the one above described, the fork employed must be adequately described. If, again, tests are made with any other sounding-forks than those which are set forth in the formula, the description of the fork employed and the duration of perception can be added behind the main formula. Exceptional methods of testing, such as Gellé's and others, must be put down with their full description.

In the case of any further quantitative tests the method in each individual case (each publication) must be clearly described, as also any graphic charts which may be employed.

The pitch of the tuning-forks and of other series of sound should be described in the following way : the notes of the scale are called *c*, *d*, *e*, *f*, *g*, *a*, *h* (= English *b* natural) ; the intermediate tones are described in the mode customary in German musical language, in so far as the lowering of a note by a semitone is indicated by the addition of *s* or *es* to the name of the original tone (for example, *des*, *es*, *as*) ; the raising of a semitone, on the other hand, by the addition of *is* (for example, *fis*, *gis*, *ais*) ; a flattened *h* is called *b*. The height of the octave is described in the following way : C_2, C_1, C, c, c^1, c^2, c^3, c^4, c^5, indicating a *C* of 16, 32, 64, 128 (*d.v.*), etc.

The vibration numbers of the tuning-forks are always expressed in double vibrations ; as an example the following may be taken as representing the tests in an imaginary case :—

AD	÷ 5	0	÷ 20	5,0	0,60	*c*	15,000
W =	a^1M (20)	a^1A (60)	c^4A (30)	*V* (28)	*v* (28)	*LI*	*LS*
AS	=	÷ 20	÷ 10	15,0	3,0	A_1	40,000

It is to be read as follows :—

A tuning-fork on the vertex is not lateralised ; in the right ear the bone-conduction is diminished, the air-conduction for a^1 is absent ; for c^4 shortened ; the hearing power for conversational and whispered voice, the test word being "twenty-eight," is somewhat diminished. The lower limit is pushed distinctly upwards, the upper limit somewhat lowered. In the left ear bone-conduction is normal, air-conduction shortened; hearing power for conversational and whispered voice somewhat diminished; the lower limit pushed somewhat upwards, the upper limit normal. Diagnosis: combined middle-ear and labyrinth disease on the right side; pure middle-ear disease on the left one.

AD	÷	÷	+ *t*	0	0,1	1,5 – 1 – 1
*W*0	a^1A (20)	c^4A (30)	*R* (35)	*H* (3,0)	*P* (15,0)	*V*
AS	÷	÷	+ 20	*a.c.*	0,5	2 – 1,5 – 1
		0		16	15,000	
		v		*LI*	*LS*	
		0,4 – 0,1 – 0,01		16	9000	

The tuning-fork upon the vertex is not heard; the air-conduction is diminished upon both sides; Rinné is positive, the fork not being heard on the right mastoid; the watch is not heard in the right ear at all, but by the left one only on contact; Politzer's acoumeter is heard on the right side at 10 cm. and on the left one at 50. Conversational voice tested with three of Quix's groups of words is only heard at a slight distance, especially those words consisting of high tones and of considerable carrying power (which under normal circumstances are heard much farther than deep tones); whispered voice is not heard on the right side, and only for a short distance on the left one; high and far-carrying tones are only heard if they are spoken directly into the ear; the lower limit normal (16 *d. v.* = C_2); the upper limit much reduced. Diagnosis: bilateral labyrinthine disease.

Examination of the Middle Ear.—*Valsalva's Method of Inflation.*—The Valsalvan method of inflation of the middle ear consists in condensing the air in the nasopharynx by means of a forcible expiration while the mouth and nasal passages are firmly closed. The condensed air is forced in the direction of least resistance up the Eustachian tubes and so into the tympanum, with the result that the membrana tympani is pushed outwards towards the auditory meatus.

The pressure which it is possible to exert by a forced expiration varies with the age, sex, and health of the individual, and to a certain extent with the "knack" of inflating the ear. In children and old and infirm people the pressure exerted is never so great as in healthy adults. Males, as a rule, are able to exert considerably more expiratory pressure than females.

The objective effect produced by a successful Valsalvan inflation upon the middle ear varies with the permeability of the Eustachian tube, the presence or absence of secretion in the tympanic cavity, the presence or absence of a perforation, and the elasticity of the membrane itself. The greater the swelling and oedema of the mucosa of the Eustachian tube the greater the difficulty of forcing air into the tympanum. The presence also of plugs of mucus in the tube or exudation in the tympanum, as well as cicatricial stenosis of the mouth or lumen of the tube, greatly interferes with successful inflation, as also does paralysis of the palatal or pharyngeal muscles.

The effect of inflation may be seen if the membrana tympani be inspected during its performance. When air enters the tympanum the membrane will be observed to bulge outwards into the meatus, and the light reflex to show a decrease in its size or to disappear entirely. The movement of the membrane is most noticeable in its posterior segment, which is considerably laxer than its anterior segment.

The effect of inflation conveys a peculiar subjective sensation to the patient, a sensation of rustling followed immediately by fulness in the ears. The surgeon, by placing his own ear against the patient's concha, or by connecting his ear to the patient's ear by means of an auscultation tube, or by placing a stethoscope over the meatus or mastoid process, may be able to hear air enter the middle ear, provided the Eustachian tube is permeable.

When the membrana tympani is perforated air may, as a rule, be heard to rush through the perforation, the sound produced varying with its size and with the presence or absence of secretion in the tympanum. In exceptional cases, when the perforation is blocked by inspissated secretion or by oedematous granulation tissue, no sound may be audible.

The Valsalvan method of inflation is of comparatively little value as a method of treatment; in fact, its over employment leads in some cases to great relaxation of the membrane and increased deafness. Further, it increases the liability to infection of the middle ear during septic states of the mouth and pharynx. As a method of diagnosis it is useful in indicating the fact of the permeability of the tube; and as a means of prognosis it possesses a certain value, as in those cases of Eustachian or tympanic catarrh, with swelling of the mucosa and exudation should the Valsalvan method suffice to inflate the tympanum, the prognosis is better than in those cases where either Politzerisation or catheterisation is necessary to effect the same object.

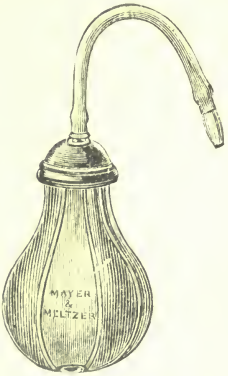

Fig. 32. Politzer's bag.

In cases of chronic suppurative otitis media inflation should be practised with great care, for fear of infecting regions previously non-infected.

Politzer's Method of Inflation.—The method of inflation of the middle ear cavities known as Politzerisation, described by Politzer in 1863,[1] is in universal use, owing, first, to its simplicity, and, secondly, to its effectiveness. The underlying principle of the method is the condensation of air in the nasopharynx during the act of swallowing, when the nasopharyngeal cavity is shut off from the oro-pharynx by the upward and backward elevation of the soft palate, and the forcing of the condensed air through the Eustachian tube into the cavum tympani.

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[1] *Wiener med. Wochenschr.*, 1863, No. 6.

For the purposes of inflation a rubber bag (Fig. 32), with nozzle containing from 8 to 10 oz. of air, is required. To avoid injury to the nasal mucous membrane and to permit of the nozzle accurately fitting the nasal passage, it is advisable to draw a piece of rubber tubing over the nozzle, or to attach to it a piece of tubing 3 to 4 inches long. In order that the surgeon may be cognisant of the effects of the inflation upon the middle ear, an auscultation tube (Fig. 33) — 18 inches in length and provided with two bone end-pieces of different colours (the one for the surgeon's use and the other for the patient's) — is employed to connect the surgeon's ear with the ear to be inflated.

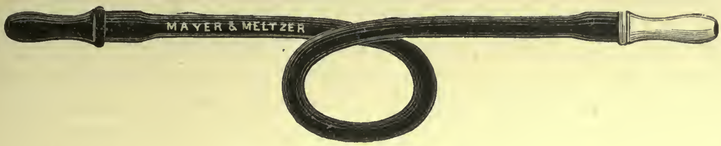

Fig. 33.—Auscultation tube.

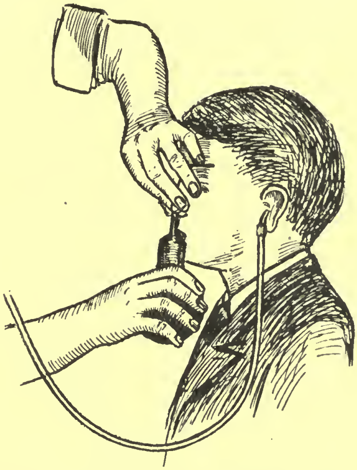

Fig. 34.—Inflation of the middle ear with Politzer's bag.

Method of Inflation.—The surgeon, standing upon the patient's right side, inserts the nozzle of the bag, held in the palm of his right hand, into one of the patient's nostrils, while he closes both passages by pressure between the thumb and index-finger of his left hand (Fig. 34).

1. The patient is provided with a little water, which at a given signal he is told to swallow. At the moment of swallowing, when the pomum Adami is seen to rise up, the bag is sharply compressed and the contained air driven up the nasal passage towards the nasopharynx. The sudden pressure forces the condensed air in the nasopharynx up the Eustachian tube, from the fact that it cannot escape through the nasal passages owing to their closure in front, nor downwards into the mouth owing to the soft palate being firmly pressed up against the posterior pharyngeal wall during the act of deglutition.

In children inflation may be performed without swallowing, owing in part to the diminutive size of the nasopharynx, and the comparative straightness, shortness, and relatively large size of the Eustachian tube.

2. The phonation of certain vowels and consonants is sufficient in many cases to permit of inflation being effectively accomplished, *e.g.* the

sounding of the vowel *a* (Lucae), or such syllables as *hic*, *huc*, *hok* (Gruber).

3. Another and more effective method of inflation (Holt) is compression of the air-bag, while the cheeks are suddenly puffed out and the lips kept tightly closed, the expiratory pressure forcing the soft palate up against the posterior pharyngeal wall.

A modification of Politzer's original method suggested by himself consists of inflation during forced inspiration. This may be accomplished by drawing air through slightly opened and pouting lips, or by inserting a small rubber tube between the lips, along which air is drawn.

Instead of swallowing water Miot has suggested the sucking of a piece of sugar, which promotes salivation and consequent deglutition.

Catheterisation of the Eustachian Tube.—The Eustachian catheter in ordinary use is a tube of from 13 to 16 cm. in length, ending in a beak of from 2 to 2½ cm., which is curved at an angle of about 145° (Fig. 35). It may be made of white metal, silver, vulcanite, or rubber. As a rule catheters made of silver or of vulcanite are employed.[1] Silver catheters possess the advantage of being sterilisable, but are not so comfortable from the patient's point of view as vulcanite instruments, which are lighter and more flexible.

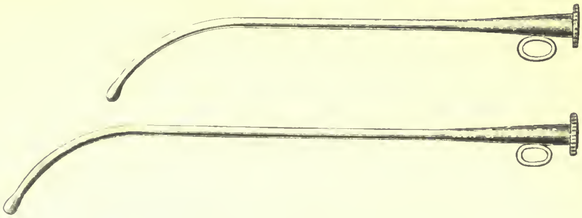

Fig. 35.—Eustachian catheters (long and short).

A metal ring is attached to the widened end of the catheter, and is fixed in such a position as to indicate the exact plane the point of the instrument is in. Hence by watching the position the ring assumes, the surgeon is cognisant of the position of the point of the instrument.

Owing to various irregularities and abnormalities in the nasal passage it may be necessary to alter the curvature of the beak of the catheter. This in the case of vulcanite catheters is effected by immersion in hot water and then bending as required.

Before introduction the catheter should be carefully sterilised. This in the case of metal instruments is readily effected by boiling. In the case of vulcanite instruments by soaking in and washing through with a solution of 1 in 1000 bichloride of mercury. It is important also to ensure that the compression bag is thoroughly sterilised.

When a patient has to submit to catheter treatment for a considerable time it is advisable that he be provided with an instrument for his own use. The greatest care should always be taken to avoid the possibility of conveying infection, *e.g.* syphilitic, from one patient to another.

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[1] The diameters of such catheters are 3½ mm., 3 mm., 2½ mm., and 1½ mm. respectively, and the thickness of the walls ½ mm.

Previous to introducing the catheter the patient's nasal passages should be carefully inspected and the position of any septal spur, deviation of the septum, enlargement of the inferior turbinated body, etc. carefully noted. To minimise the pain and discomfort of passing the Eustachian catheter the nasal passages should be sprayed with a 2 to 4 per cent solution of cocaine in albolene, and the patient should cleanse the nostrils of mucus by "blowing the nose."

Position of the Patient and Surgeon.—The patient should be seated upon a high-backed chair, and the surgeon seated immediately in front. In order to steady the head the surgeon should place the outstretched fingers of his left hand upon the patient's forehead, and with his left thumb tilt up the point of the nose, the head being horizontal, *i.e.* the auditory meatus on the same level as the nostrils. The catheter, held gently between the first and second fingers of the surgeon's right hand, and poised upon the thumb, is now introduced *vertically* into the nasal passage until the anterior nasal spine lies well within its beak (Fig. 36). It is then rotated through a right angle until its point is in contact with the floor of the nose, and is pushed gently but swiftly forwards along the floor of the inferior meatus until it impinges against the posterior pharyngeal wall, the sensation imparted being as if it were being pressed into the palm of the hand.

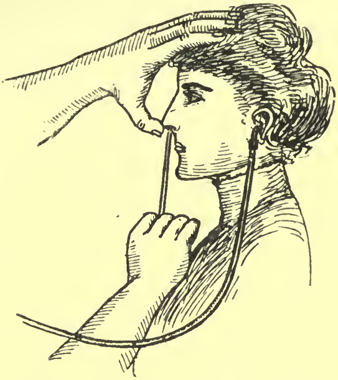

Fig. 36.—First step in the introduction of the Eustachian catheter into the nasal passage.

Various methods are in use to secure the entry of the instrument into the mouth of the Eustachian tube.

1. The method advocated by *Bonnafont* consists in making use of the posterior lip of the Eustachian tube, the *plica salpingo pharyngea*, as the geographical landmark.

The point of the catheter having reached the posterior pharyngeal wall is turned outwards into Rosenmüller's fossa, while the proximal end of the shaft is inclined towards the nasal septum. The instrument is then gently withdrawn, and, as it is being withdrawn, slips over the posterior lip of the tube into its mouth. To make sure that the point of the catheter is actually lying within the mouth of the tube, the instrument is rotated so that its eyelet and the external canthus of the patient's eye are in the same inclined plane (Fig. 37).

Such an amount of rotation is not necessary in all cases, the point of the instrument lying at times within the mouth of the tube when the eyelet is horizontal.

2. *Loewenberg's Method.*[1]—The posterior border of the nasal septum is taken as the geographical guide. The catheter, after having been passed to the posterior pharyngeal wall, as already described, is turned so that its point looks towards the opposite Eustachian tube, and its ring lies horizontally.

It is then withdrawn until its beak impinges upon and engages the posterior border of the nasal septum, after which it is rapidly moved through an angle of 180°, so that its point, which formerly looked towards the mouth of the opposite tube, now looks towards the mouth of the tube of the same side. Provided that the instrument is neither drawn outwards nor pushed backwards towards the posterior pharyngeal wall, the effect of its complete rotation should be to insert its tip within the mouth of the tube.

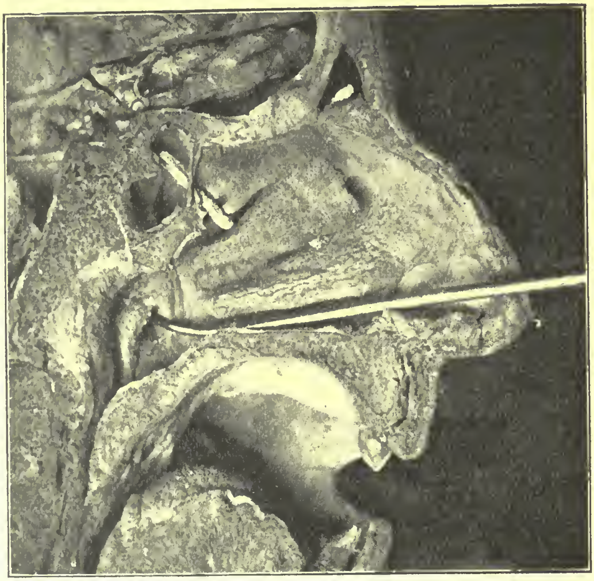

FIG. 37.—Eustachian catheter in the mouth of the Eustachian tube.

Difficulty is frequently encountered in rotating the instrument by reflex contraction of the muscles of the soft palate, which tend either to prevent rotation altogether or to force the instrument backwards. This reflex irritability may, as a rule, be overcome by firm traction, or by spraying the posterior surface of the palate with cocaine, or by ordering the patient to breathe through the mouth and nose regularly and freely, except at the moment when the bulb is compressed.

3. *Lincke's Method.*—In this method the catheter is pushed backwards until its tip touches the posterior pharyngeal wall. It is then withdrawn

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[1] *Archiv f. Ohrenheilk.* vol. ii. p. 127.

until its concavity comes into contact with the posterior surface of the soft palate. If it is then rotated outwards about a half circle, its point should engage the ostium tubae.

The main objections to this otherwise simple method are that the position of the soft palate varies, and that its muscular resistance and tension alter with the pressure with which it is engaged by the beak of the catheter.

In cases where the musculature of the soft palate is very irritable a useful plan is to pass the catheter backwards with its point upon the nasal floor until the nasopharynx is all but reached. It is then turned outwards until the metal ring assumes an almost horizontal position. If pushed backwards while in this position its point will enter the orifice of the tube without coming into contact with the soft palate, while it will be prevented from slipping into Rosenmüller's fossa by the presence of the posterior lip of the tube.

Method of Inflation.—The catheter having been passed into the mouth of the Eustachian tube, is gently but firmly retained in position by holding its proximal end between the thumb and index finger of the left hand, the remaining three fingers resting upon the bridge of the patient's nose. The nozzle of the air-bag, which is held in the surgeon's right hand (Fig. 38), is then introduced into the mouth of the catheter and the bag gently compressed. A column of air is in this way driven up the Eustachian tube into the cavity of the middle ear, its entrance being made known to the examiner by means of the auscultation tube.

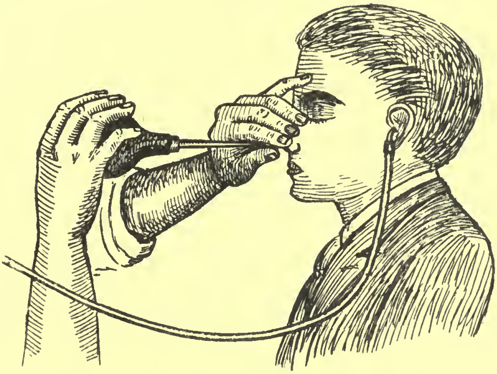

Fig. 38.—Inflation of air into the middle ear, the Eustachian catheter *in situ*. (Note the position of surgeon's hands.)

In cases where no stenosis of the tube is present air will be found to enter the tympanum quite freely. Where, on the other hand, there is some degree of tubal stenosis considerable pressure may be required to force a passage.

When inflation is difficult the act of deglutition by opening up the tube materially assists the entrance of air into the middle ear.

Too great force should never be used for fear of lacerating the mucosa, and so producing emphysema.

Submucous nasopharyngeal emphysema, which is a distinctly rare occurrence, is prone to spread downwards towards the larynx, upwards towards the tympanic cavity, and forwards to the cheeks. Its presence gives rise to a certain degree of pain, dysphagia, and at times dyspnœa.

If untreated it usually passes away in a few days. In severe cases incisions through the mucosa of the soft palate and posterior pharyngeal wall may be necessary (Guye).

The effect inflation has upon the middle ear and its contents may be studied by means of the auscultation tube, by inspection of the membrane, and by noting the effect upon the hearing power.

The auscultation tube should invariably be employed when inflating the middle ear to ascertain, in the first place, if inflation has been successful, and, in the second place, the character of the sounds produced, which are frequently of considerable diagnostic importance.

If a normal middle ear be inflated the sound conveyed to the examiner's ear has been compared by Politzer to that produced by placing the tongue against the hard palate and making a quick expiration with the mouth slightly open. When the sound produced by inflation is weak and distant, some form of tubal obstruction in all probability exists. If, on the other hand, the sound is of a crackling or bubbling nature, a diagnosis of mucous or sero-mucous catarrh may safely be made. If the membrane be perforated the sound produced varies with the size and position of the perforation. Thus where the perforation is small the sound is high pitched and shrill; when it is large the note produced is of a loud blowing character, and gives an impression of nearness.

In cases where the membrana tympani is very much indrawn, but not adherent to the pars promontoria, successful inflation produces an immediate click or thud which is very characteristic. When intratympanic adhesions are present the sound produced is of a crepitating or creaking nature, the result of the gradual retraction of previously stretched adhesions. These various sounds are more readily heard and more easily interpreted if the tympanum is inflated by means of the Eustachian catheter rather than with Politzer's bag. This is due partly to the fact that Politzerisation may be unaccompanied by any distinct sound, and partly because the act of swallowing fluid or pronouncing gutturals may entirely mask the more delicate sound produced in the tympanum.

Inspection of the membrane after inflation of the middle ear yields valuable information. Thus a membrane previously retracted will be found to bulge outwards towards the meatus, a cicatrix which previously had been slightly depressed will be blown out in the form of a small balloon, and a collection of mucus which prior to inflation had occupied the lower part of the tympanum will be found dispersed in the form of small highly refractile bubbles over the surface of the membrane. The existence of a minute perforation will be made more obvious from the fact that a bubble of fluid or air will be seen projecting through it. In the case of a dry slit-like (valvular) perforation no change is visible.

The mobility of the membrane and ossicular chain may also be demonstrated as the result of inflation, by noting the relative positions of the various structures before and after the entrance of a current of air into the tympanum.

To measure the excursions of the membrane as the result of inflation an ear manometer may be used. This little instrument (Fig. 39) consists of a bent horseshoe-shaped glass tube of fine bore, with a rubber plug at one end which fits the auditory meatus tightly. A few drops of coloured fluid or red ink are put into the tube. When the tympanum has been successfully inflated the pressure of air in the meatus will be considerably increased, with the result that the fluid in the bent glass tube will be found to rise. A negative Valsalvan experiment will, on the other hand, cause it to fall.

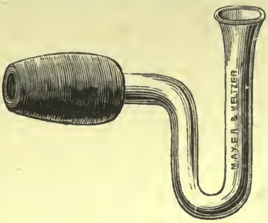

FIG. 39.—Ear manometer.

Effects of Inflation upon Audition.—Information of a most important kind is derived from observing the effects of inflation upon the patient's hearing power. If in a case of deafness with intact membrane the amount of hearing improves immediately after inflation and remains improved for a few days, a relatively good prognosis may be given; if, on the other hand, the improvement is very evanescent, the prospects of recovery are not so good. Speaking generally, it may be said that the more rapid the improvement and the longer it lasts the better the prognosis.

An increased amount of deafness and a feeling of fulness in the ears at times follows immediately after inflation, and may be due either to undue stretching of intra-tympanic structures or to slight labyrinthine concussion.

In middle-ear disease capable of improvement inflation produces a beneficial effect of longer or shorter duration according to the underlying pathological conditions present; in labyrinthine disease it invariably acts prejudicially.

The Valsalvan method of inflation is of comparatively little value beyond demonstrating the fact that the Eustachian tube is pervious and the membrane movable. It is at times of service in revealing the presence of a minute perforation. As a method of treatment it should not be recommended, as it is extremely liable to be abused and to ultimately produce an unduly relaxed condition of the membrane.

When inflation is easily accomplished, and when no improvement takes place, *e.g.* in undue permeability of the tube, oto-sclerosis, etc., the prognosis, so far as the restoration of hearing is concerned, is bad.

Catheterisation from the Opposite Nasal Passage.—In cases of unilateral nasal stenosis, or when it is desired to save the patient the discomfort of passing the catheter along both nasal passages, catheterisation of both tubes may at times be effected from the one nasal passage. When the nasopharynx is small and narrow in its transverse diameter catheterisation may be performed with an ordinary catheter.

When, however, it is large and roomy the beak of the catheter must be considerably elongated. This is accomplished by immersing the instrument in boiling water until it is softened, and then bending it until its beak is from 20 to 25 mm. in length.

The instrument is then introduced in the ordinary way as far as the posterior pharyngeal wall. Its point is subsequently rotated towards the opposite Rosenmüller's fossa, and until the metal ring lies in the horizontal plane. By drawing the stem of the instrument away from the septum and towards the outer nasal wall the point of the instrument comes to lie deeply in Rosenmüller's fossa. Then by gently drawing the instrument forwards it is made to slip over the posterior lip of the tube and so into its orifice.

Catheterisation through the Mouth.—In exceptional cases where both nasal passages are impermeable, or where one passage is impermeable and catheterisation through the free one is not successful, inflation may still be successfully accomplished by passing a specially constructed form of catheter through the mouth. The instrument (Fig. 40) is passed along the dorsum of the tongue, which is in the meantime kept depressed until it has reached the posterior pharyngeal wall. It is then directed upwards, backwards, and outwards until it reaches Rosenmüller's fossa. Its point is then drawn across the posterior lip of the tube until it drops into and engages its orifice.

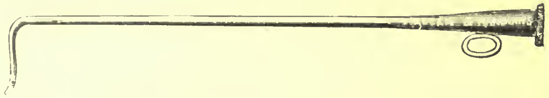

FIG. 40.—Baber's Eustachian catheter (for use through the mouth).

By now gently pushing the instrument upwards and backwards the Eustachian tube is entered.

In cases where a cleft palate exists the orifices of the Eustachian tubes are at times visible from the mouth. Under such circumstances the passage of the catheter is rendered comparatively easy.

Where, on the other hand, the *ostium tubae* is not visible its posterior lip may be seen at times running downwards. This serves as a guide over which the instrument is drawn.

Various circumstances contribute to mistakes in catheterisation.

1. The catheter, instead of being kept upon the floor of the nose, may be passed upwards into the region of the middle meatus. Rotation of its beak then becomes impossible (Fig. 41).

2. The catheter, having been introduced as far as the posterior pharyngeal wall, is insufficiently withdrawn, its point remaining in Rosenmüller's fossa.

3. The catheter is too much withdrawn, and so passes over the mouth of the tube into the space between its anterior lip and the posterior extremity of the inferior turbinated body.

4. The catheter is insufficiently rotated after having reached the nasopharynx, and so passes *above* the orifice of the tube.

5. The catheter, having been correctly introduced into the mouth of the tube, is not made to engage it sufficiently, with the result that its

axis and that of the tube are not in the same inclined plane. The air which is inflated does not therefore reach the tympanum.

6. The catheter, after having reached the nasopharynx, may be over-rotated, with the result that its point is directed upwards towards the nasopharyngeal vault.

The Injection of Fluids into the Middle Ear through the Catheter.—In certain cases of middle-ear disease the injection of fluids into the cavum tympani is indicated, and is at times followed by improved audition and a diminution of tinnitus.

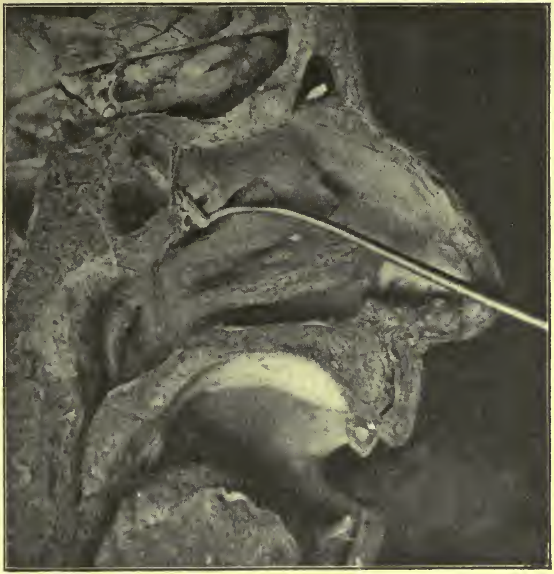

Fig. 41.—Faulty method of passing the Eustachian catheter. Catheter in middle meatus.

The indications for such intra-tympanic injections are—

1. In cases of otitis media accompanied by swelling of the tympanic mucosa and the presence of thick inspissated secretion.

2. In cases of anchylosis of the ossicular joints the result of previous hypertrophic catarrhal otitis media.

3. In cases of chronic suppurative otitis media with inspissated secretion in the tympanum.

The injection of fluids into the middle ear is frequently rendered difficult on account of tumefaction of the mucous membrane of the Eustachian tube and mechanical difficulties in passing the catheter. A certain amount of the medicament employed invariably escapes into the nasopharynx and pharynx on account of the conformation and shape of the mouth of the Eustachian tube. The farther the catheter is passed up the tube, and the more its orifice corresponds with the direction of the tube, the greater the amount of fluid which reaches the middle ear.

When the Eustachian tube is so stenosed, or where the middle ear is so full of inspissated secretion or oedematous mucosa that fluid injected through the catheter does not reach its cavity but flows back into the nasopharynx, it is necessary to make use of a Weber-Liel's tympanic tube (Fig. 42). This little instrument, 17 cm. long and $1\frac{1}{4}$ mm. in thickness, consists of a hollow vulcanite tube with a funnel-shaped extremity. It is introduced through a good-sized Eustachian catheter to the mouth of the tube, and is then gently pushed onwards for a distance of $2\frac{1}{2}$ to 3 cm. beyond its point, by which time it should have reached the tympanum. The fluid to be injected is then forced along its lumen by means of an air-bag, care being taken not to employ too much pressure, otherwise severe pain and vertigo may be complained of.

When a perforation of the membrane already exists large quantities of fluid may be injected to wash out inspissated secretion, cholesteatomatous débris, etc., which it has been found otherwise impossible to remove.

Where, on the other hand, the membrane is imperforate only a small quantity of fluid should be injected at any one sitting, otherwise severe reaction may be induced, ending at times in suppurative inflammation.

Fig. 42.—Weber-Liel's intra-tympanic tube.

The introduction of medicated vapours into the middle ear is not much practised, from the fact that it is now recognised that comparatively little of the vapour ever reaches the tympanic cavity in those cases where the Eustachian tube is stenosed, cases where vapour might *a priori* be expected to exercise some beneficial influence. A simple method of introducing volatile vapours is to hold an emptied Politzer's bag over the mouth of a bottle of chloroform or ether, and to allow it to gradually fill; then to insert the nozzle of the bag into the mouth of the catheter, and to forcibly drive the vapour onwards. In cases of very impermeable stricture compressed and medicated air may be employed with advantage.

The writer is in the habit of attaching the nozzle of a spray connected with a compressed-air apparatus to the mouth of a catheter previously introduced into the Eustachian tube, and of so driving the volatilised fluid and vapour into the middle ear.

In uncomplicated cases the vapour selected may be blown into the middle ear by means of Politzer's air-douche, the nozzle of the bag being furnished with a chamber for the reception of a medicated sponge or piece of wool, through which the air is driven.

For self-use Dundas Grant's Eustachian self-inflator has, in the writer's experience, frequently proved serviceable.

The entrance of medicated vapour into the middle ear is accompanied by a feeling of warmth and fulness, and by the objective indication of congestion along the handle of the malleus.

The Method of making Intra-Tympanic Injections.—After the application of cocaine to the nasal mucosa the Eustachian catheter is first passed and air injected by means of Politzer's bag, so as to get rid of any secretion in the tube itself, and to ensure the catheter being in proper position. A few drops of the medicament to be employed, previously warmed, are injected into the catheter by means of a small syringe—the patient's head meantime being kept quite horizontal—and subsequently driven on into the cavum tympani by forcible inflation with Politzer's bag, the patient performing the act of swallowing while the bag is compressed.

The fact that fluid has reached and entered the middle ear is recognised by the sounds heard through the auscultation tube.

When the membrane is intact sharp sounds akin to fine crepitations are heard.

Upon inspection bubbles of air and fluid may sometimes be seen scattered over the surface of the membrana tympani, while the blood-vessels along the handle of the malleus and around the periphery of the membrane become injected and consequently visible.

The subjective sensations produced are a feeling of warmth and fulness in the ear and at times acute pain, also giddiness, and a temporary increase of deafness.

Inflammatory reaction is uncommon, provided that the injected fluids have been previously sterilised.

To relieve pain following an intra-tympanic injection massage of the tissues in front of the tragus, instillation of warm glycerine into the meatus or the application of a pad of warm spongiopiline over the auricle are efficacious.

The following solutions are employed for intra-tympanic medication:—1 per cent solution of bicarbonate of soda, chloride of sodium, or iodide of potassium; sterilised water, sterilised liquid vaseline; ½ per cent solution of cocaine hydrochloride. It is, however, very doubtful if any more benefit results from the injection of fluids into the middle ear than from the air pressure required to drive the fluid onwards.

Massage of the Membrana Tympani and Ossicular Chain.—This may be effected by means of Lucae's pressure-probe, Siegle's speculum, Delstanche's masseur, Sondermann's cup, or one or other of the many forms of hand or electro-motor masseurs.

Lucae's pressure-probe (Fig. 43) is employed for the immediate massage of the ossicular chain. After having anaesthetised the membrane the cup-shaped dome of the instrument is placed over the *processus brevis* of the malleus and a gentle to and fro pressure exerted. By this means the chain of ossicles is mobilised. The application of the probe is usually, however, so painful that few patients will tolerate it. The results are, as a rule, also inferior to those obtained by pneumo-massage. The probe is at times, however, of service in the treatment of chronic catarrhal adhesive processes in the middle ear and in cases of oto-sclerosis. The various hand instruments, *e.g.* Delstanche's (Fig. 44), have recently been almost entirely supplanted by electro-motor instruments designed by Breitung, Seligmann, Chevalier Jackson, Lake and others. The number of strokes per second, the length of the stroke, and the duration of treatment are determined partly by the pathological conditions present and partly by the effect produced. In very chronic middle-ear cases with high degrees of deafness the duration of any one treatment may be made considerably longer than in recent and less aggravated cases. The greater the deafness the greater the amount of pressure required to produce an effect. When pressure causes pain, dizziness, or sickness it must be at once reduced. In many cases of chronic middle-ear catarrh pneumo-massage appears to cause a temporary improvement, relieves fulness in the head, and at times subjective noises in a marked degree. It should never be employed in acute inflammatory affections or in diseases of the internal ear.

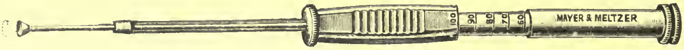

Fig. 43.—Lucae's pressure-probe.

Its value in cases of oto-sclerosis is very doubtful. According to the experience of the writers, it is of no value whatever, and in certain cases has appeared to accelerate the morbid process.

M'Leod Yearsley has found pneumo-massage of considerable service, especially in those cases of adhesive middle-ear catarrh where the movements of the ossicular chain are becoming restricted. He employs Lake's oto-masseur driven by an electro-motor, by means of which the number of strokes can be raised from 3000 to 18,000 per second. The duration of treatment should not, at first at any rate, exceed five to ten seconds.

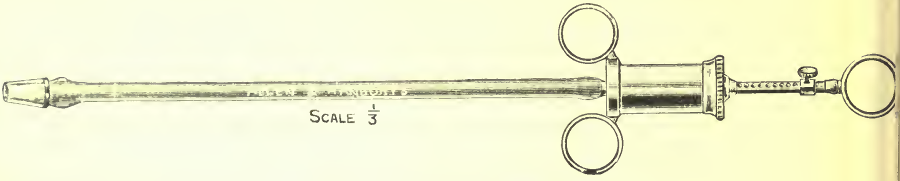

Fig. 44.—Delstanche's masseur.

Paracusis Willisii.—Patients suffering from certain forms of deafness frequently hear better in a noise, *e.g.* in a railway train, in a tramway car, etc. This phenomenon is designated Paracusis Willisii on account of its discovery by Willis in 1680. Various theories have been adduced in explanation of this apparent anomaly, that of Politzer being the one usually accepted, viz. that the improvement in hearing is due to a general shaking up of the ossicular chain whose joints have been more or less anchylosed from an existing inflammatory lesion. The vibrations felt, as when travelling in a railway carriage, by throwing the ossicular chain out of equilibrium increase the capability for the transmission of sound. Others, *e.g.* Loewenberg, Urbantschitsch, explain the phenomenon as due to increased irritability of the acoustic nerve, whereas Müller believed it to be due to torpor of the auditory nerve. It may occur also when there is excessive laxity of membrane and ossicles, in which case the phenomenon is removed on tightening the membrane by collodion or using an oiled or glycerine tampon.

In stapes-anchylosis low tones are not well perceived. Hence, according to Siebenmann and von Tröltsch, the noise produced by the rattling of a railway train or tramway car is not heard, whereas words spoken, and generally spoken more loudly than is usual, are heard by the patient.

Paracusis Willisii is a comparatively late symptom in chronic adhesive catarrh of the middle ear, but a very early one in oto-sclerosis. It is usually regarded as a very unfavourable sign.

According to M'Leod Yearsley[1] its presence should be looked upon more as an indication for treatment.

Diplacusis, or "hearing double," occurs occasionally, either every sound or only certain tones being heard twice. It is met with most frequently in middle-ear affections, *e.g.* serous or purulent otitis media. According to Wittick it occurs in cases of simultaneous implication of the middle and internal ears. Two types are recognised, viz. "diplacusis dysharmonica" and "diplacusis echoica." In the former the affected ear hears a higher or a lower tone than the normal ear; in the latter the sound is heard later as an echo.

Paracusis Loci.—The capacity of accurately judging as to the direction of sound depends upon the possession of binaural hearing. Where the acuity of the perception of sound is not the same upon both sides the power of determining its direction is frequently interfered with.

Hyperacusis, or an increased sensibility to sound, is met with at times in hysterical and neurasthenic patients whose hearing is otherwise normal. It may last a few minutes or even a few hours.

It is at times complained of by those who over-indulge in alcohol and tobacco, and is fairly common immediately after the removal of impacted cerumen.

It has also been noted as a forerunner of meningitis, encephalitis, and various febrile disorders.

Testing very Deaf Patients.—To test patients suffering from high grades of deafness, a bell, a whistle, distinette, or a tuning-fork may be employed. Clapping the flattened-out palms of the hands together is also serviceable. During the process of testing the patient's eyes should be kept turned away from the source of sound, and all elements of vibration carefully excluded. When any sound is heard the patient's face lights up at once, so that its expression should be carefully watched by the examiner. Even deaf-mutes are usually capable of hearing certain sounds on account of the preservation of "islands of hearing" (p. 509).

Local Anaesthesia.—To produce efficient local anaesthesia for the performance of minor ear operations several solutions are in use.

Politzer recommends equal parts of cocaine hydrochloride, carbolic acid, and menthol; A. Gray a 10 per cent solution of cocaine hydrochloride in equal parts of aniline oil and absolute alcohol; T. Barr a solution of carbolic acid, 4 minims; cocaine hydrochloride, 8 grains; menthol and rectified spirit, 80 minims.

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[1] *Text-book of Diseases of the Ear.*

The solution should be slightly warmed, and allowed to remain in the previously cleansed meatus for ten minutes prior to operation.

A more efficient method suggested by Neumann of Vienna is carried out as follows:—

A special syringe (Fig. 45), with a capacity of 1 cm., and with the needle fixed at an obtuse angle to the main stem is required.

Three solutions are employed for infiltration—

1. A 1 to 2000 solution of adrenalin chloride, with a 1 per cent solution of eucaine.

2. A 1 to 3000 solution of adrenalin chloride, with a 1 per cent solution of cocaine.

3. A 20 per cent solution of cocaine.

The method is mainly of use in operations upon the tympanic cavity, *e.g.* paracentesis, removal of polypi, ossiculectomy, etc. To produce anaesthesia the external ear is drawn forwards, and the needle thrust into the soft tissues between the auricle and mastoid process. Several drops of the eucaine solution are then injected. A large speculum is now introduced into the meatus, and pressed against its posterior wall in such a way as to make the skin at the deep end of the cartilaginous meatus rise up in a fold. A few drops of the solution are then injected into this fold, and the needle gradually pressed farther and farther inwards, more solution being injected in order to anaesthetise the deeper portions of the tympanum.

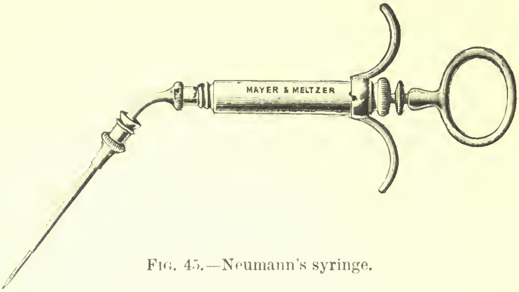


Fig. 45.—Neumann's syringe.

Where it is desired to anaesthetise the tissues in order to perform a mastoid operation the needle is inserted into the skin about the centre of the mastoid process, and a few drops of the cocaine solution injected.

Note.—The solution must be sterile. Codrenine (P. D. & Co.) in hermetically sealed ampullae is a convenient form of solution.

It is then worked upwards towards the zygoma, backwards towards the occiput, and finally downwards towards the apex so as to produce anaesthesia over the whole process. Should it be necessary to perform a complete post-aural operation, the cavity of the middle ear is also anaesthetised as detailed above. The advantage of the method is that for minor operations it is sufficient, and allows of the work being done with the patient sitting upright and in the ordinary position for examination. The surgeon should wait for at least ten minutes before commencing the operation. The advantages of the method are—(1) The production of efficient anaesthesia, (2) a bloodless field, and (3) an anaesthesia of at least half an hour's duration.

The diseases of the nasal passages which are most prone to implicate the ear are those associated with obstruction or suppuration, or with both obstruction and suppuration at one and the same time. Among the former are rhinitis acute or chronic, hypertrophic rhinitis, deflection of the nasal septum, large septal spurs, post-nasal adenoids and intermittent or vasomotor rhinitis; among the latter are suppurative disease of one or more of the nasal accessory sinuses, purulent rhinitis, and atrophic rhinitis especially when associated with accessory sinus suppuration.

Of these various morbid conditions the one most frequently associated with tubo-tympanic changes is post-nasal adenoid vegetations, partly on account of the obstruction they produce, and partly also because their presence induces and maintains a constant state of post-nasal catarrh and sepsis. The symptoms incident to long-continued nasal obstruction, from whatever cause arising, are numerous and varied. One of the most important and constant is the habit of mouth breathing which in severe cases is present both by day and by night. In milder cases mouth breathing may only be noticeable during sleep, the patient when awake having the power of inspiring sufficient air through the nose to supply his requirements. Upon the least exertion, however, or upon the accession of any superadded catarrhal attack, nasal respiration has to be supplemented by oral. The habit of constant mouth breathing leads in time to certain well-marked facial changes especially about the nose and lips. The bridge of the nose becomes gradually broadened out, while from disuse the alae nasi muscles become atrophied, flaccid, and flattened, with a resulting pinched expression. The lips, more especially the lower lip, become thickened and everted, the mouth more and more open, and the jaw depressed.

Progressive changes are also produced in the palate, the alveoli, and the teeth. The hard palate becomes arched and V-shaped, and the alveoli pressed together in such a way as to cause the upper jaw to override the lower with resulting "open bite" (Lack). The teeth become crowded, erupt irregularly, and the upper incisors markedly projecting.

As a consequence of long-continued nasal obstruction general development is interfered with, especially the development of the chest. The ribs, at the line of junction with their corresponding cartilages, sink in, while the sternum is arched forwards (pigeon breast). The deficient aeration of blood induced by the obstructed nasal passages leads to a varying degree of mental lethargy and want of purpose. When associated at the same time with deafness a condition of *aprosexia* (Guye) is induced, the individual being apparently mentally dull and unable to concentrate his attention. Frontal headache is also a common symptom. The speaking voice loses its normal resonance and becomes "nasal," and there is a marked inability to pronounce certain consonants. Thus *m* and *n* are pronounced *b* and *d*, such a word as *common* being pronounced *cobbod*. At the same time the singing voice becomes muffled and hoarse. The habitual open mouth leads to dryness of the pharyngeal mucosa and tends to induce laryngitis, bronchitis, etc.

Certain digestive disturbances are also prone to occur, such as coated tongue, foul breath, and dyspepsia, with the result that nutrition is interfered with and a consequent want of development ensues.

Air hunger, which in severe cases of nasal obstruction is a common symptom, especially at night, leads to disturbed sleep, unpleasant dreams and nightmare.

Another important result of any form of nasal obstruction, especially when associated with sepsis of the accessory cavities, is the presence of bacteria, pathogenic and non-pathogenic, in the nasopharynx with an obvious liability to invade the middle ear.

This fact is of the utmost importance since in the normal healthy adult the nasopharynx is perfectly sterile, a condition which the writers have proved by special investigation. During infancy the nasopharynx is so exceedingly small as to be almost part of the mouth cavity, and therefore the Eustachian ostium from its position is much more liable to infection from the mouth than is the case in adults. In adults also any form of nasal obstruction interfering with ventilation and drainage predisposes to sepsis of the nasopharynx.

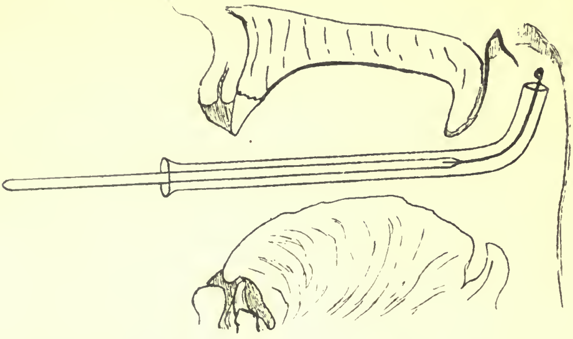


FIG. 46.—Wingrave's cannula for collecting material from the nasopharynx for bacteriological examination.

Bacteriological examination by means of a special cannula (Fig. 46) has further shown that the cavity is anything but sterile in cases of persistent nasal obstruction with or without aural complications, a point for consideration in the exercise of Politzer's method of inflation.

Examination of the Pharyngeal, Nasal, and Nasopharyngeal Cavities.—To secure a satisfactory view of the pharyngeal and nasal cavities it is necessary to employ artificial light reflected by means of a forehead or hand mirror. Daylight (sunlight more particularly) is sufficient to enable the examiner to obtain a direct view of the pharynx, but is rarely sufficient to permit of the indirect examination of the nasal or nasopharyngeal cavities. Any one of the varieties of light already mentioned for the examination of the ear (p. 23) may be employed. For operative work the electric light or the oxyhydrogen limelight is to be preferred.

The mirror used to reflect the light should have a focal diameter of from 8 to 10 inches. It may be mounted upon a forehead band (Vienna pattern) or upon a spectacle frame with nose-pads or flexible metal loop.

Position of Patient and Examiner.—The patient should be seated directly in front of the examiner upon a straight-backed chair and in such a position that the examiner's eyes and the patient's nose are in the same horizontal plane. As a rule it is preferable to have the light placed upon the patient's left side and on a level with his ear. Some surgeons, however, prefer to have the light upon the patient's right side, claiming that there is less risk of it being obstructed by the operator's hand.

When the pharyngeal mucosa is peculiarly irritable, and the nasal passages are obstructed by swelling of the turbinal mucosa, a preliminary spraying with a 4 per cent solution of cocaine is useful.

In making an examination it is advisable to follow a definite plan, viz. to examine :—

1. The buccal cavity.
2. The pharyngeal cavity.
3. The anterior nasal chambers.
4. The post-nasal space or rhino-pharynx.

Pharyngoscopy.—The teeth should be carefully inspected by inserting a spatula into the angle of the mouth and drawing the cheek outwards, on account of the important part they play in the production of oral sepsis and the intimate relationship of oral sepsis to morbid conditions of the throat and ears.

The lips, the gums, the tongue, and the floor of the mouth should also be minutely scrutinised, and finally the palate. To obtain a good view of the palate, especially of the hard palate, the patient's head should be tilted slightly upwards and backwards.

To examine the faucial pillars and their mobility, the region of the tonsil, the soft palate, and the post-pharyngeal wall, it is, as a rule, necessary to depress the patient's tongue. Some patients have, however, the faculty of so controlling the tongue as to permit of an uninterrupted view of the whole pharyngeal space when the mouth is held widely open.

Various forms of tongue depressors are in use, the main essentials of a good instrument being sufficient breadth to prevent the tongue arching over its sides, and a suitable form of handle so as to prevent the examiner's hand obstructing the rays of light which are being reflected into the mouth (Fig. 47). The spatula should be applied firmly but gently to the dorsum of the tongue in the middle line while downward and forward pressure is made. Provided that pressure be made firmly and equably there is comparatively little risk of the patient retching so long as he keeps the mouth well open and inspires gently through it and through the nose.

In children the application of the forefinger to the dorsum of the tongue acts as a capital depressor. In unruly children who will not open their mouths to permit of an examination the firm closure of the nostrils for a few seconds compels an almost immediate opening of the mouth. When the musculature of the tongue is irritable the continuous application of firm pressure brings about a state of fatigue followed by the sinking of the tongue into the floor of the mouth. The pronunciation of the sound *ah*, or better the sound *err* or *air*, by causing an elevation of the soft palate permits of a still fuller view of the posterior pharyngeal wall.

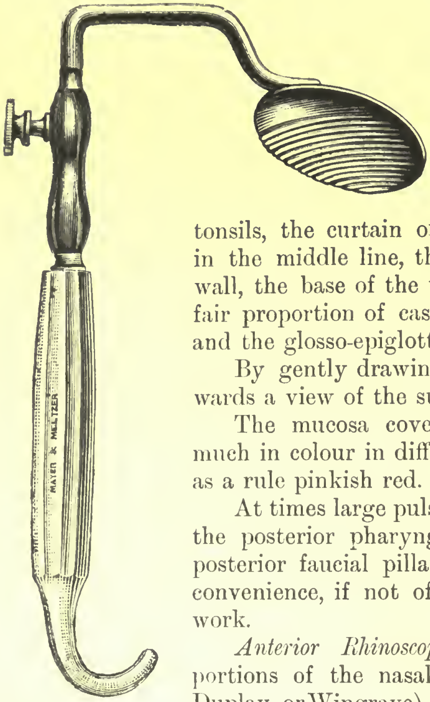


FIG. 47.—Türck's tongue depressor.

The parts seen by pharyngoscopy are the anterior and posterior faucial pillars with the tonsils, the curtain of the soft palate with the uvula in the middle line, the mucosa of the post-pharyngeal wall, the base of the tongue with its papillae, and in a fair proportion of cases the free edge of the epiglottis and the glosso-epiglottic fold.

By gently drawing the anterior faucial pillar forwards a view of the supra-tonsillar fossa is obtained.

The mucosa covering these various parts varies much in colour in different individuals in health, being as a rule pinkish red.

At times large pulsating blood-vessels are seen upon the posterior pharyngeal wall, especially behind the posterior faucial pillar, and are a source of great inconvenience, if not of actual danger, during operative work.

Anterior Rhinoscopy. — To examine the anterior portions of the nasal passages a bivalve (Thudicum, Duplay, or Wingrave), tubular or self-retaining speculum is required. The outstretched fingers of the surgeon's left hand should be placed upon the patient's forehead and the tip of the nose tilted upwards with the thumb. A strong beam of light reflected from a forehead mirror is then thrown upon the nose and the vestibule, columella and anterior portions of the cartilaginous septum scrutinised. The speculum, previously warmed, is then introduced into the nasal passage and its blades gently separated so as to dilate the vestibule.

The head being held horizontally, the anterior end of the inferior turbinated body, of a red or reddish-pink colour, is at once seen, and immediately below it the inferior meatus into which the lachrymal duct opens. The surface of the inferior turbinated body in the normal state is smooth and glossy, in certain pathological conditions corrugated or papilliform. Immediately above and behind the inferior turbinal is situated the middle turbinated body, while between them lies the middle meatus, into which the infundibulum and ostium maxillare open. These two openings are connected to a greater or lesser extent by opening into a shallow groove—the *hiatus semilunaris*. In certain cases this groove is well developed and serves as a gutter which conducts discharge from diseased fronto-ethmoidal cells to the maxillary antrum, which then acts as a reservoir, and vice versa. These are all under cover of the anterior end of the middle turbinal. The lower and anterior border of the hiatus semilunaris, the *processus uncinatus*, forms a distinct ridge covered by mucous membrane and becomes at times so hypertrophied as to resemble the middle turbinated body, the so-called "cleavage" of the middle turbinal. Above and behind the hiatus semilunaris is seen a marked projection, the *bulla ethmoidalis*, which is the largest and at the same time the most dependent of the anterior ethmoidal cells which open either upon the bulla or into the groove between the bulla and the middle turbinal.

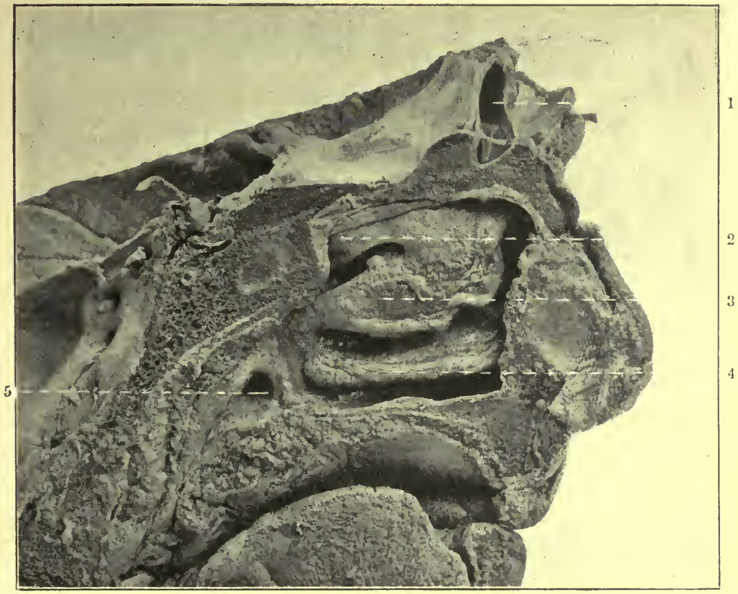


FIG. 48.—Sagittal section of nasal cavity (wet preparation). (1) Frontal sinus, (2) superior turbinal, (3) middle turbinal, (4) inferior turbinal, (5) Eustachian tube.

Above the middle turbinal is situated the superior meatus, a portion of which may at times be seen from the front.

Examination of the anterior nasal passages is much facilitated by the local application to the mucosa of a 2 to 4 per cent solution of cocaine hydrochloride with or without adrenalin.

Posterior Rhinoscopy.—To obtain a good view of the post-nasal space requires considerable practice and deftness of manipulation. The instruments required are a tongue depressor, a small post-nasal mirror, a forehead mirror, and, in exceptionally difficult cases, a palate retractor.

The patient should be seated upon a straight-backed chair directly in front of the examiner, the source of light being placed upon his left-hand side and on a level with his ear. Where considerable nasal stenosis is present it is advisable to spray the nasal passages with a 4 per cent solution of cocaine hydrochloride, and in irritable patients spraying of the anterior surface of the soft palate and posterior pharyngeal wall is also advisable. A good preliminary drill is to direct the patient to blow out a match by blowing through the nostrils with the mouth widely open. The tongue should then be gently but firmly depressed and the patient told to breathe quietly through the nose or to enunciate the French word "err" or air. In this way the soft palate is relaxed and falls away from the post-pharyngeal wall, thus affording more room for the manipulation of instruments. The post-nasal mirror, previously warmed, is now introduced behind the soft palate (great care being taken to avoid touching its mucosa) and the reflecting surface turned upwards. If the mirror be held in the middle line and directed forwards and upwards, the posterior border of the vomer is at once recognised as a vertical ridge covered by mucous membrane somewhat paler than that covering surrounding parts. As a rule it appears as a sharply defined line, although occasionally in the neighbourhood of its attachment to the hard palate it is slightly thickened and nodular. Upon either side of the middle line are seen the posterior nares or choanae, and projecting from their outer walls the three turbinated bodies, viz. the superior, middle,

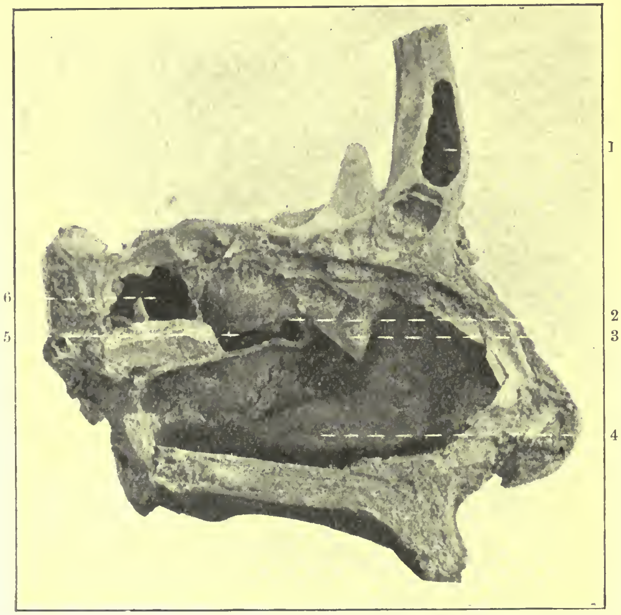


FIG. 49.—Sagittal section of nasal cavity (dry preparation). (1) Frontal sinus, (2) ostium maxillare, (3) anterior end of middle turbinal, (4) inferior turbinal, (5) bulla ethmoidalis, (6) sphenoidal sinus.

and inferior. In the majority of cases a good view of the posterior ends of the middle and superior turbinals is obtained with the corresponding superior and middle meatuses. The posterior end of the inferior turbinal (when normal) is frequently imperfectly seen on account of the arching of the soft palate. When pathological, however (hypertrophied, moriform, etc.), it projects backwards into the post-nasal space and becomes clearly visible. By turning the mirror to one or other side the lateral walls of the nasopharynx become visible with the orifice of the corresponding Eustachian tube and the fossa of Rosenmüller. The pharyngeal orifice of the Eustachian tube is triangular in shape and is bounded posteriorly by a prominent ridge of cartilage—the cushion—while anteriorly it shades off into the mucosa of the lateral pharyngeal wall.

The Eustachian cushions are at times very prominent and project into the cavity of the nasopharynx. Between the cushion and the post-pharyngeal wall is situated the fossa of Rosenmüller.

By inclining the surface of the mirror upwards the roof or vault of the nasopharynx is seen and also a small portion of the post-pharyngeal wall.

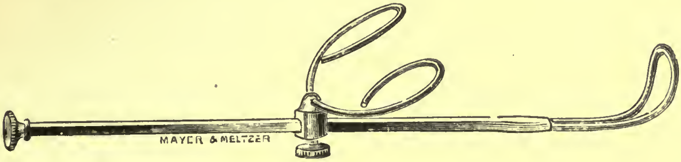


Fig. 50.—White's palate retractor.

In those cases where the space between the soft palate and the posterior pharyngeal wall is very small, or where the patient is unable to breathe in such a way as to permit of the soft palate falling away from the posterior pharyngeal wall, it may be necessary to employ a palate retractor, *e.g.* White's (Fig. 50). After having cocainised the pharyngeal mucosa the retractor is slipped up behind the soft palate, which is at once drawn forwards. The movable clip is then adjusted over the upper lip so as to keep the retractor in position.

Instead of the self-retaining palate retractor india-rubber bands may be passed through the nasal passages, brought out through the mouth, and then fixed over the upper lip.

By drawing the palate forwards a greater amount of space for examination is secured, and a larger post-nasal mirror may be employed.

Information of an extremely important kind is to be obtained from the use of the post-nasal mirror. In children the most common pathological condition found is hypertrophy of the pharyngeal tonsil (post-nasal adenoid vegetations). The amount of hypertrophy, its position, and its relation to the Eustachian tubes, the extent of obstruction to respiration and the presence or absence of pus may readily be noted. Associated with post-nasal adenoids there is at times found hypertrophy of the posterior ends of the inferior turbinals.

In adults an antral (maxillary) polypus, ulceration of the mucosa of the lateral pharyngeal walls, stricture of the orifice of the Eustachian tube, adhesions and cicatricial bands are at times to be seen.

A flow of pus over the posterior end of the middle turbinated body from suppuration of the posterior ethmoidal cells or sphenoidal sinus is also at times to be noted.

The pharyngoscope recently invented by Harold Hays of New York is of value in the examination of the pharyngeal and naso-pharyngeal spaces.

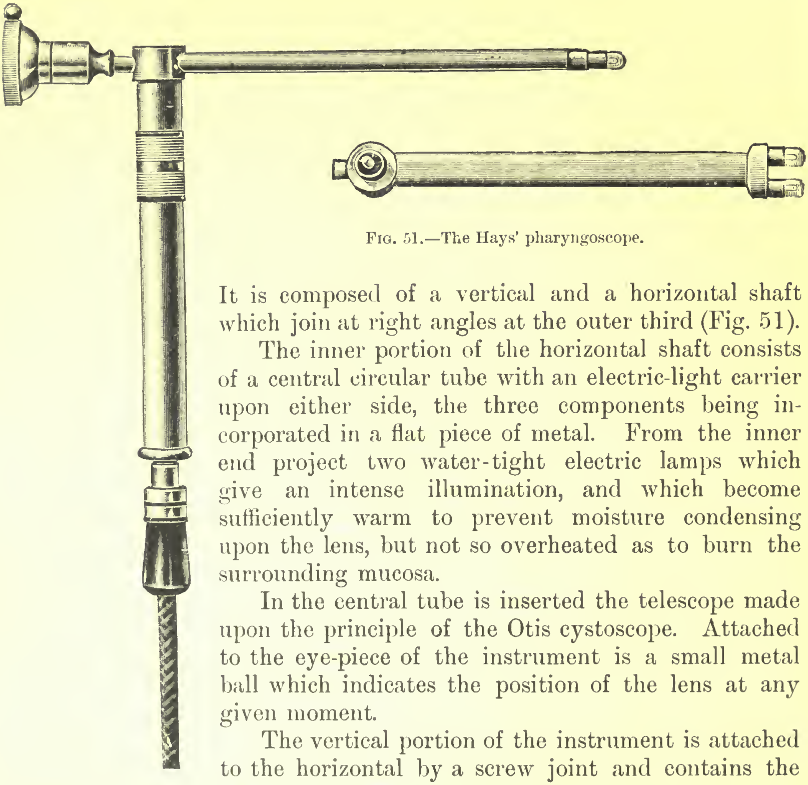


Fig. 51.—The Hays' pharyngoscope.

It is composed of a vertical and a horizontal shaft which join at right angles at the outer third (Fig. 51).

The inner portion of the horizontal shaft consists of a central circular tube with an electric-light carrier upon either side, the three components being incorporated in a flat piece of metal. From the inner end project two water-tight electric lamps which give an intense illumination, and which become sufficiently warm to prevent moisture condensing upon the lens, but not so overheated as to burn the surrounding mucosa.

In the central tube is inserted the telescope made upon the principle of the Otis cystoscope. Attached to the eye-piece of the instrument is a small metal ball which indicates the position of the lens at any given moment.

The vertical portion of the instrument is attached to the horizontal by a screw joint and contains the wires for connection with a rheostat. An arrangement is provided for cutting off the current so that the lamps need not be kept burning until the instrument is in the mouth and in position.

The instrument is placed in the mouth like a tongue depressor and in such a manner that the inner end of the telescope is about one-sixteenth of an inch from the posterior pharyngeal wall. When once in position the patient is requested to close his mouth and to breathe through his nasal passages (Fig. 52). To prevent his breathing directly upon the examiner's face a small mica plate is fixed between the telescope and the horizontal shaft.

When the lens points upwards, as indicated by the position of the ball upon the eye-piece, a view of the pharyngeal vault is obtained. When rotated to the side, as indicated again by the position of the ball, the mouth of the Eustachian tube and lateral pharyngeal wall come into view. Although the instrument is useful mainly for diagnostic purposes, it may also be employed to control local applications to the mucosa of the nasopharynx when made through the nose.

Digital Exploration of the Post-Nasal Space.—In children, where it is frequently impossible to obtain a good view of the nasopharyngeal space with the mirror, digital examination should be resorted to.

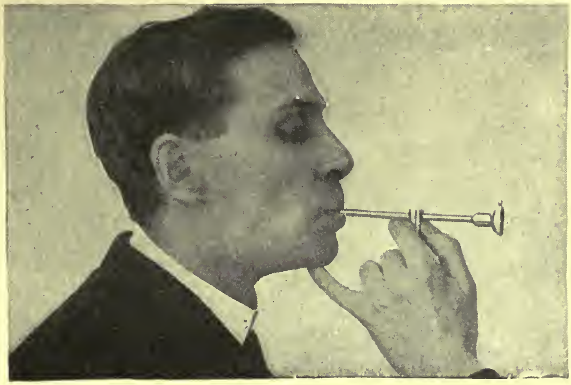


Fig. 52.—Hays' pharyngoscope in position for examination.

The patient is seated upon a chair or held in a nurse's lap. The surgeon, standing behind, places the child's head in his left arm-pit and firmly against his body. The index finger of the right hand, previously well washed, is slipped into the patient's mouth as far as the posterior pharyngeal wall. To prevent its being bitten the patient's left cheek should be pushed between his teeth by the surgeon's left index finger. The surgeon's right index finger is then slipped up behind the soft palate into the post-nasal space, and swept rapidly from side to side, feeling for the Eustachian cushions, the fossae of Rosenmüller, and the posterior border of the vomer. The presence of any growth, its position, and its consistence may thus readily be made out.

CHAPTER VI

DEFORMITIES OF THE EXTERNAL EAR

Deformities of the external ear, apart from those due to inflammatory lesions and neoplasms, will be considered in two groups—developmental and traumatic.

1. **Developmental.**—In accord with the developmental scheme of the auditory apparatus deformities of the auricle and meatus are generally associated with abnormalities of the antro-tympanic cavity, and occur quite independently of the labyrinth, whose origin is distinct and separate. Bezold has shown that in sixteen cases of abnormalities of the external ear and tympanum the labyrinth was normal in ten.

With regard to the auricle its deformity is generally due to either absence or impaired development of the primary tubercles surrounding the margin of the hyomandibular cleft (Fig. 53). These tubercles may be suppressed, may fail to fuse, or may wander from their proper position. Of these the one most frequently involved is the tragus, which may be found in most remote places, on the cheek, or the neck, or as a supernumerary structure. This deformity is generally attended by pits or dimples, said to represent partially obliterated relics of the branchial cleft. These pits or dimples often contain a milky discharge, wrongly described as purulent, as it really consists of fluid and fatty epithelial cells not unlike "colostrum." Such a discharge occurs also from other fistulae, *e.g.* in the middle line of the neck from an unobliterated thyro-hyoid duct. They may also be the seat of acute or chronic septic infection.

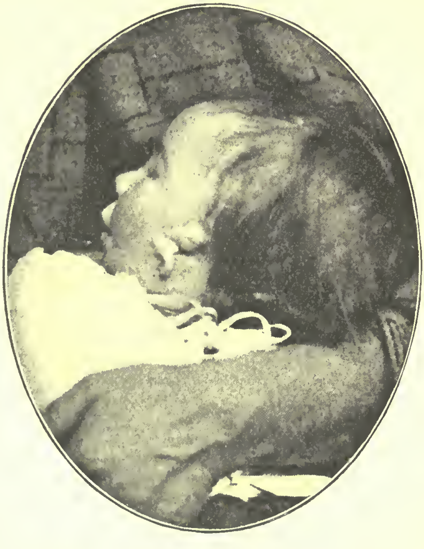
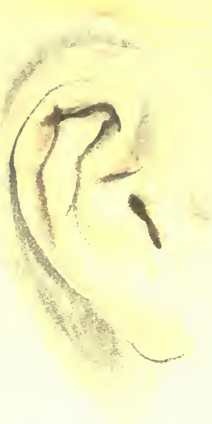


Fig. 53.—Congenital malformation of auricle.

PLATE I



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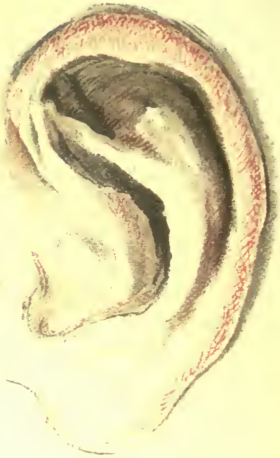

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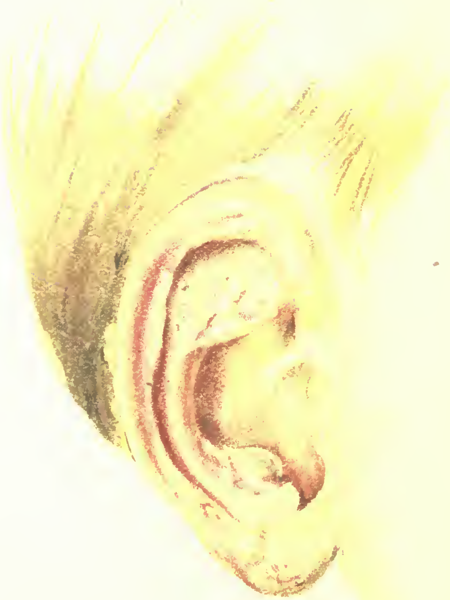

3

Fig. 1.—Irregular microtia. Fig. 2.—Complete absence of meatus.

Fig. 3.—Eczema of auricle.

To face page

Rudimentary and accessory auricles are by no means uncommon in the lateral cervical region, and are familiar objects in ancient sculptures of fauns and satyrs.

Exaggeration of the helicine process and a notch in the upper region of the helix is a very common deformity constituting an hereditary and even social type. The exaggeration or suppression of all or any of these rudiments of the pinna with dimples, flattening of the fossae, etc., frequently constitute individual and family peculiarities. Finally, the whole auricle may be uniformly enlarged (macrotia) or diminished (microtia), or may be unduly prominent and unsymmetrical in its relation to the head, particularly in deaf-mutes. Such deformities are further often associated with other abnormalities, such as coloboma iris, cleft palate, hare-lip, hairy moles, web-foot, polydactylism, etc.[1]

Plate I. Fig. 1 illustrates a common type of irregular microtia, in which the auricle is but partially and unsymmetrically developed as an elongated roll-like structure deficient in cartilage in its lower part. In this case the labyrinth was fully developed, as evidenced by the presence of good bone conduction, although there was no visible meatus.

Meatus.—In association with extensive abnormalities of the pinna the meatus is nearly always involved, the deformity varying in degree from a mere diaphragm or septum to complete absence (Plate I. Fig. 2). When such is the case abnormal mobility of the auricle will be found so much exaggerated that its attachment to the bony margin is sufficiently loose to enable one to readily identify the presence or absence of the tympanic annulus, an important point in considering the practicability of a plastic operation for restoring the meatus. Should the annulus be present and the Eustachian tube patent the existence of a useful tympanic apparatus is probable.

Post-rhinoscopic examination and Eustachian inflation, aided by a stethoscope placed over the region of the meatus, should always be resorted to when the meatus is obliterated.

Deformities of the *osseous meatus* are of three kinds—

1. Excessive size, of which there are four examples in the Toynbee collection.

2. Narrowing, owing to imperfect development of the tympanic annulus.

3. Clefts or dehiscences, which can only be observed on dissection. Six examples of these are to be seen in the Toynbee collection, all of which are situated in the floor of the canal, and are evidently due to imperfect union of the anterior and posterior ossifying limbs which grow outwards from the tympanic annulus.

2. **Traumatic Deformities.**—These are for the most part the result of injury either by direct violence during parturition or in after life, *e.g.* othaematoma, injudicious piercing of the lobule, and irritation from earrings. The last cause is well illustrated by Fig. 54 from a patient who presented a hard, firm, solid mass in the substance of the lobule, consisting of densely packed fusiform cells and white connective-tissue fibres similar in structure to keloid. It was removed with complete

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[1] J. Evans, *B.M.J.* April 1, 1899, p. 793.

restoration of symmetry and no recurrence after an interval of four years. It is an example of exaggerated sclerotic hyperplasia which may result from any form of irritation.

The lobe may be elongated or torn, either condition readily admitting of cosmetic restoration.

Tympanic Membrane.—Developmental anomalies of the tympanic membrane are somewhat rare, except in connection with those of the meatus and antro-tympanic cavity. Complete absence invariably accompanies non-development of the tympanic bone. Imperfect absorption of the embryonic jelly filling the tympanum may be responsible for various forms of adhesion to the promontory, etc., while perforations and clefts may be due quite as much to imperfect union of the epiblast, mesoblast, and hypoblast at this important point of meeting as to inflammatory processes at a later stage. Abnormalities of the membrana tympani are frequently found in association with cleft palate, coloboma iris, etc.

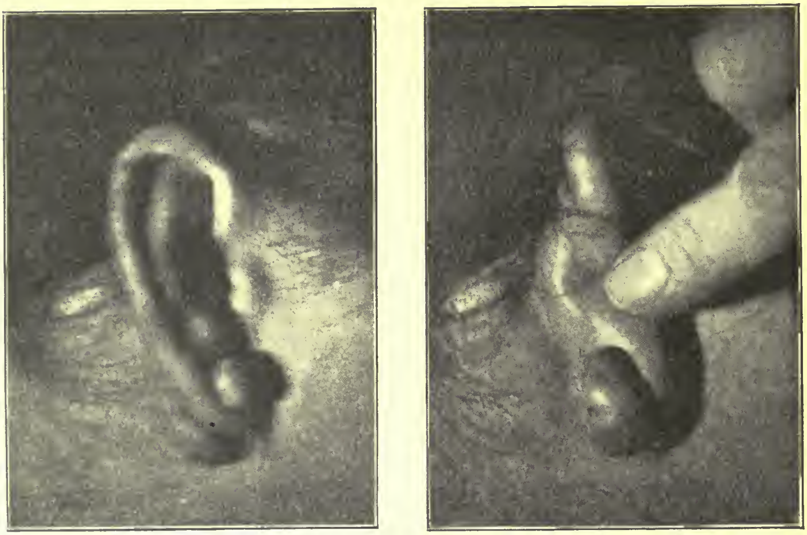

FIG. 54.—Keloid of lobule, anterior and posterior view.

Deformities resulting from disease are fully dealt with elsewhere.

The results of plastic operations for restoration of meatal abnormalities are not very encouraging. When the hearing power is good, and little more than a diaphragm or septum requires removal, operation *per meatum* may afford excellent results. When, however, a considerable distance separates the meatal dimple from the tympanic ring, or the whole meatus is merely represented by a solid cord of fibrous tissue, the post-aural route should be selected, but may result in disappointment for many reasons. A case is related by Kelson,[1] in which it was necessary to abandon the completion of the operation owing to an unsuspected communication with the temporo-mandibular joint. In the absence of a well-defined tympanic ring associated with marked deafness and absence of an Eustachian tube any attempt at surgical interference is unjustifiable.

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[1] *Trans. Otol. Soc.* vol. vi. p. 44.

3. **Supernumerary Auricles** (*Polyotia*).—Cases have been recorded where supernumerary auricles have been found in various parts of the head and neck. Such supernumerary appendages vary in number, and are occasionally hereditary. They are frequently associated with other developmental abnormalities, such as branchial fistula, hare-lip, cleft palate, coloboma iris, etc. Such auricles, although misplaced, are at times fairly perfect in form, at other times mere rudimentary pieces of skin or cartilage. They are always congenital, and as a rule unilateral, although at times bilateral and symmetrical.

They have a soft and elastic feel, and are composed of white fibro- or elastic cartilage covered with connective or adipose tissue and skin with delicate soft hairs.

Treatment.—Such irregularly placed auricles may be removed surgically. A flap of skin of sufficient size to cover the raw surface about to be produced should be carefully dissected from the surface of the supernumerary auricle, and folded over the exposed area from which it has been removed and fixed with horse-hair sutures.

4. **Deformity of the Auricle** (*Microtia*).—Microtia is a congenital deformity in which the ear is hardly, if at all, developed. The skin representing it may contain cartilage. It is usually associated with lack of development of some portion of the organ of hearing. The treatment of microtia is, as a rule, very unsatisfactory. Something may at times be done to improve appearances by the removal of small projecting portions of skin and cartilage, or by preparing the part for the wearing of an artificial pinna.

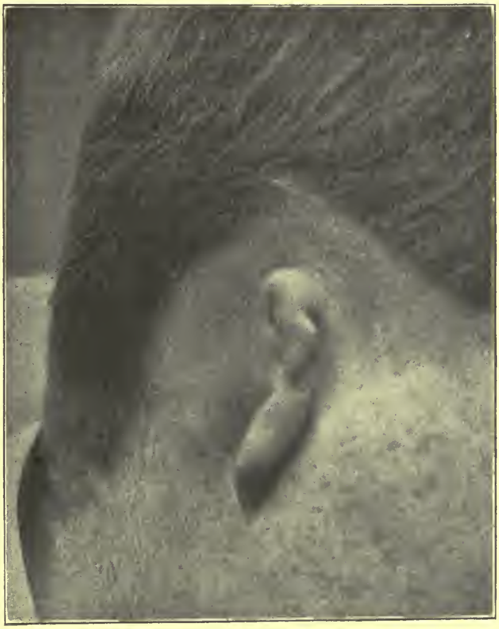

FIG. 55.—Microtia and congenital malformation of auricle.

In cases where a dimple is present in the situation of the auditory meatus it is advisable, provided that the patient is old enough to give definite information from a functional examination, to make an exploratory opening in order to ascertain if a meatus and tympanic membrane are present. A crucial incision should be made through the centre of the dimple, and the skin and subcutaneous tissues raised from the underlying bone with an elevator. Careful search is then made for an osseous meatus and tympanic ring. If found, the meatus should be carefully enlarged by means of a small bur, and the triangular flaps already formed folded inwards and retained in position by gauze packing. Should nothing suggestive of an osseous meatus be observed, it is inadvisable to perform any exploratory operation, as the exact location of such important structures as the facial nerve, the lateral sinus, and the base of the middle fossa cannot be ascertained beforehand.

Treatment of Abnormally Large Auricles (*Macrotia*).—In cases where one auricle is very much larger than its fellow, or where both auricles are abnormally large, the resulting deformity may be corrected by means of the removal of a wedge of tissue, the size of which is estimated according to the necessities of the case. Much judgment is required to effect a symmetrical and satisfactory appearance. After the wedge has been excised the cut surfaces of the auricle are very carefully adjusted and sutured with horse hair.

5. **Deformity of the Auricle** (*Outstanding Auricle*).—An undue prominence of one or of both auricles, combined in certain cases with a varying degree of malformation, is by no means uncommon. The deformity produced is not only unsightly but is also a source of great annoyance to the patient, and should, whenever possible, be corrected by some form of surgical interference. In slight cases the application of a bandage or special pad applied shortly after birth may serve to effect an improvement.

Little reliance is, however, to be placed upon a method so uncertain and so slow in its action. Surgical interference is usually called for, and should be undertaken as soon as the child has been weaned. In simple cases, and in those uncomplicated by any actual malformation of the external ear, the removal of an elliptical piece of skin from over the mastoid process and posterior surface of the auricle, the amount to be removed varying with the degree of deformity, and the subsequent suture of the cut edges is sufficient to produce at times marked improvement. In more complicated cases it is advisable to remove a portion of the cartilage as well. After the field of operation has been carefully disinfected, an incision is made through the skin of the posterior surface of the pinna, beginning at the level of its attachment to the side of the head, and continued downwards and as far outwards as is deemed necessary to correct the extent of the deformity. The incision is then carried through the cartilage, great care being taken to avoid injury to the cutaneous covering of the anterior surface of the auricle. The skin and underlying cartilage are then dissected backwards to the retro-auricular groove, and a corresponding segment of the skin covering the mastoid process likewise removed. The cut edges, including also the cartilage of the pinna, are then carefully brought together and sutured with four or five interrupted stitches.

Collodion is painted over the line of incision, a pad of gauze placed behind the ear, and a roller bandage applied.

If judgment has been exercised in the amount of tissue removed the result is frequently very gratifying.

Where one auricle is larger than its fellow the judicious removal of a wedge of skin and cartilage is at times advisable. Both the vertical and horizontal diameters of the auricle may in this way be successfully reduced. Careful judgment is called for in estimating the amount of tissue to be removed.

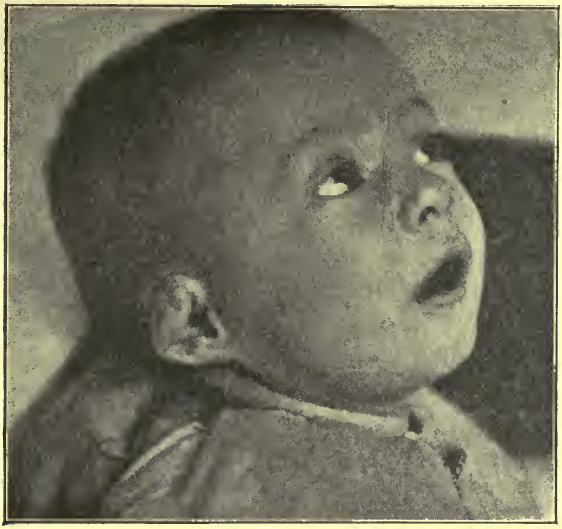

Fig. 56.—Malformed and outstanding auricle.

6. **Fistula Auris Congenita** (*Persistent Branchial Cleft*).—This congenital anomaly is situated either in front of or below the tragus, upon the side of the face in front of the helix, or in the neck in front of the sternomastoid muscle, and consists of one or more tubules of varying size and length, which open upon the surface of the skin, and which end blindly in the subcutaneous connective tissue.

Each tube is lined by a layer of columnar ciliated epithelium secreting a white milky-looking exudation, which consists of a thin opalescent fluid containing three kinds of cells—

1. Leucocytes, generally polynuclear; occasionally a mononuclear lymphocyte is to be seen.

2. Large, round, or cubical epithelial cells, often containing bright refractive drops of a fatty nature suggestive of "colostrum" corpuscles. Sometimes the cytoplasm is granular. The nucleus is oval and situated eccentrically.

3. Nucleated and non-nucleated squames belonging to and corresponding with epidermal cells.

Under no circumstances do these fistulae communicate with the external or middle ear. They are occasionally found bilaterally and symmetrically, and are due to incomplete closure of the second branchial cleft. They may be hereditary. The existence of a *fistula auris congenita* is of no practical importance, except in those cases where a retention cyst or localised abscess forms.

Treatment.—In certain cases no treatment is called for. In others, where on account of excessive secretion or the formation of an abscess or retention cyst pain and discomfort are experienced, it is necessary to eradicate the tubule.

To effect this it is essential to completely dissect the tubule from its surroundings, the dissection having at times to be continued down to and occasionally into the cartilage of the external ear.

All attempts to obliterate by means of curettage or escharotics are invariably disappointing.

CHAPTER VII

INJURIES OF THE AURICLE AND EXTERNAL AUDITORY MEATUS

Injuries of the External Ear.—Injuries of the external ear may be produced as the result of blows, falls, cuts, stabs, scalds, or contusions. Superficial injuries confined to the skin and subcutaneous connective tissues heal readily and without subsequent deformity. When, however, the perichondrium and the cartilage are involved cicatricial contraction with subsequent deformity is almost invariable. Incised wounds, even if extensive, also heal readily, provided that the cut surfaces are accurately brought together and sutured.

As the result of wearing too heavy ear-rings or of violence, the lobule is at times torn through, giving rise to a most unsightly deformity, which is, however, easily rectified by paring the edges of the cleft and by the insertion of horse-hair or fine silk-worm gut sutures.

Lacerated wounds of the auricle and bites are at times followed by considerable sloughing and subsequent deformity. Injuries of the cartilaginous meatus are occasionally associated with injuries of the auricle and are equally amenable to treatment. Superficial injuries of the cutaneous lining of the meatus are not infrequently produced by clumsy efforts to extract foreign bodies, and are occasionally followed by the formation of tufts of exuberant granulation tissue, by cicatricial contraction and stenosis, or by the formation of webs.

Injuries of the osseous meatus caused by direct violence, as in the extraction of foreign bodies or the introduction of hard metallic objects with the idea of relieving some local irritation, are comparatively rare. They are at times followed by an otitis externa diffusa (p. 130) or by periostitis.

Injuries of the osseous meatus from indirect violence, such as fracture of the base of the skull or violent blows upon the lower jaw, occur more frequently, their situation and extent depending upon the nature of the trauma.

Thus when great violence has been applied to the top of the head fracture of the superior wall of the meatus may occur, if to the occiput fracture of the posterior meatal wall, and if to the lower jaw fracture of the anterior meatal wall.

Fracture of the osseous meatus is not infrequently followed by necrosis and sequestration of small pieces of bone, by purulent inflammation of the middle ear or adjoining mastoid cells, by basal meningitis, or by the formation of osseous growths, the particular complication depending largely upon the site of injury and subsequent suppuration.

When the membrana tympani is ruptured there is often profuse haemorrhage. Should the injury involve the capsule of the labyrinth or the cranial cavity there is an escape of cerebro-spinal fluid, frequently lasting for days, accompanied in the former case by dizziness, tinnitus, and profound deafness, which is rarely if ever recovered from. In many cases, however, the fissure passes by the side of the labyrinth across the tympanum and through the superior osseous wall of the meatus (Fig. 57).

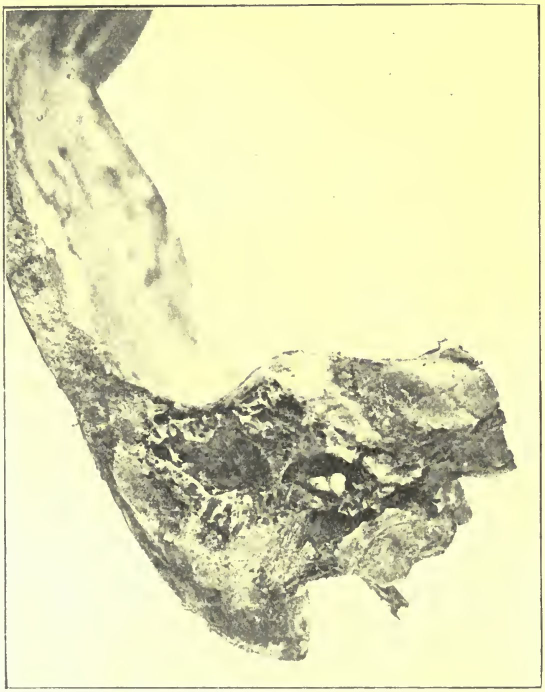

Fig. 57.—Fracture of the temporal bone showing the line of fracture passing by the side of the internal ear through the middle ear and roof of the auditory meatus.

Injury to the auricle and walls of the meatus occasionally follows gunshot wounds. In a case seen by the writer the projectile passed through the face and across the meatus, and emerged through the upper and posterior portion of the mastoid process. The membrana tympani and the ossicular chain were hopelessly destroyed. Injury from chemical caustics, molten metal, burns and scalds are also not uncommon. In a case coming under the writer's care where molten lead had accidentally spluttered up into the meatus the soft tissues were eroded with exposure of the underlying bone, the middle ear was entirely destroyed, and the facial nerve paralysed. In a case due to scalding complete atresia of the meatus and adhesion of the auricle to the side of the head resulted.

From the medico-legal point of view injury to the external ear, especially if at the same time the middle and internal ear are involved, is of great importance. In minor injuries, cuts, stabs, contusions, etc., complete healing takes place as a rule without permanent disability. Where, however, the tympanum or the internal ear or both are simultaneously damaged the case should be regarded from the following standpoints:—

1. Is the injury of a temporary or permanent nature?
2. Does it involve the hearing power, and consequently the ability of the individual to earn his livelihood, and if so, to what extent?
3. Is it likely to prove dangerous to life?
4. Was the ear in a healthy condition prior to the receipt of the injury?

In coming to a definite conclusion it is very necessary to be on the outlook lest malingering or evidence of previous disease be overlooked. The fact that previous disease has, however, been present is in a legal sense no mitigation.

The medico-legal aspects of injury to the middle or internal ears will be considered under their respective sections.

CHAPTER VIII

DISEASES OF THE AURICLE

1. **Furuncular Inflammation of Auricle.**—Furuncular inflammation of the skin of the auricle occurs at times as the result of furunculosis of the auditory meatus and from the injudicious use of poultices and irritating applications.

It gives rise to considerable pain and swelling of the affected parts, and in chronic cases leads to induration of the auricle.

Treatment should be conducted upon general antiseptic lines. To relieve the acute pain the application of warm lead and opium lotion is advisable, followed by smearing the inflamed parts with resorcin and cocaine ointment.

Localised collections of pus should be promptly evacuated.

In chronic cases auto-vaccine treatment may be employed with advantage.

2. **Frost-Bite.**—As the result of continuous and severe cold, or prolonged hypertonicity of the muscular coats of the small arteries, paresis or paralysis of the vaso-dilators of the cutaneous blood-vessels supplying the auricle is induced with consequent arrest of circulation and at times localised gangrene.

In mild cases a superficial erythema followed by dermatitis is produced, but in the more severe type vesicles or bullae form, which at times rupture and lead to painful excoriations.

In exceptionally severe cases ecchymoses form, followed by gangrene, necrosis of tissue, and permanent cicatricial deformity. Hyperaesthesia or anaesthesia of the auricle is occasionally an after result of frost-bite.

Treatment.—In the first instance the auricle should be bathed with ice-cold water and gently massaged.

When the circulation has been re-established warm and soothing applications should be applied, followed by friction with menthol ointment (menthol, 10 per cent; balsam Peru, 1 per cent; vaseline, 100), or painting with a mild and stimulating liniment.

In those cases where painful excoriations are present the application of dilute nitrate of silver (gr. x. to xx. to 1 oz.) followed by an ointment containing cocaine and boracic acid, or cocaine and acetate of lead, is beneficial. In recurrent or chronic cases the internal administration of chloride or iodide of calcium is useful.

3. **Ossification of the Auricle.**—Partial or extensive ossification of one or of both auricles has been described, as has also ossification of the inferior wall of the cartilaginous meatus.

The amount of new bone deposited may be ascertained by means of an *x*-ray photograph.

4. **Cysts of the Auricle.**—These are of three kinds: (1) Retention cysts, (2) Dermoid cysts, and (3) Serous cysts.

The former are situated in the skin proper, and are due to blocking of a sebaceous duct followed by multiplication of the epithelium and distension of the gland walls. Since they are generally exposed to intermittent irritation the walls become thickened by fibroplastic changes. They may assume considerable size. At any time acute inflammation may take place attended by suppuration. The sac, usually situated in the skin, is lined by nucleated squamous epithelium. The contents are non-nucleated. They are usually situated upon or immediately behind the lobule (Fig. 58).

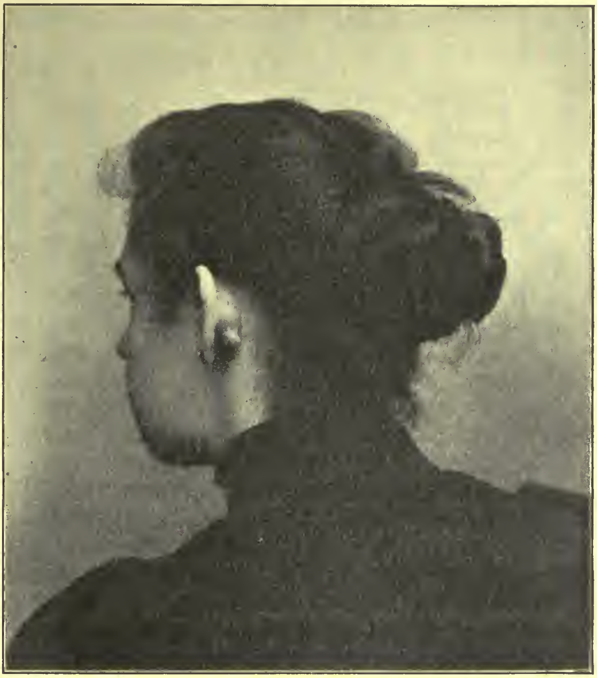

Fig. 58.—Retention cyst of auricle.

The Dermoid type is always situated below the skin, which may be freely movable over it. Sometimes a dermoid cyst occurs in the cartilage which it may replace. It is enclosed in a definite capsule which contains a pale straw-coloured fluid, giving it at times a translucent appearance. If examined by transmitted light a sharply defined nodule is found at one point occupying a small part of the cyst. This on opening is found to consist of a pearly mass of concentrically laminated scales, similar to a cholesteatoma, probably the relic of an early epidermal inclusion or "rest."

In both kinds the cells are non-nucleated acid-fast squames, only mixed with leucocytes in the event of an inflammatory process occurring.

Flattened rhombic crystals of cholesterin are found in the contents of both retention and dermoid cysts.

Symptoms.—Pain is rarely complained of, except when rupture is about to take place or when suppuration occurs. The amount of deformity produced varies with the size and situation of the cyst.

Sebaceous cysts are freely movable and impart to the fingers the sensation of an elastic swelling.

Treatment. — In those cases where the cyst has already ruptured its contents should be scraped out and its wall completely excised. Where, however, rupture has not taken place an incision should be made over the swelling and down to the wall of the cyst. With a blunt dissector the cyst is carefully separated from the surrounding tissues, the greatest care being taken to avoid injury to its walls. After removal of the cyst the edges of the incision are brought into accurate apposition and carefully sutured with horse hair or ophthalmic gut. In the event, however, of the cyst rupturing or being injured during the process of dissection, every effort should be made to remove all traces of its wall, otherwise recurrence is practically certain. After removal of the ruptured cyst wall the surrounding tissues should be curetted with a sharp spoon or cauterised with chloride of zinc (gr. xx. to 1 oz.) and a small dressing inserted, the original incision being left partly unsutured. An ordinary surgical dressing is then applied. Recovery without deformity is the rule.

Serous cysts are by no means common. When they occur their usual situation is the fossa of the anthelix, and they may originate in the cartilage. This form may assume considerable size. It often occurs as a cystic distension around a small cholesteatoma which may be seen by transillumination as a small dark object attached to one side of the transparent cyst.

Treatment is removal by dissection.

5. **New Formations.**—From the clinical standpoint new formations springing from the tissues of the external ear may be divided into two main groups, the benign and the malignant.

The former includes such growths as fibromata, keloids, atheromata, angiomata, tuberculous granulomata, papillomata, etc., the latter carcinomata, endotheliomata, and sarcomata.

From their histological structure they may be arranged into two divisions according to their origin, those arising from the connective-tissue elements of the auricle, mesoblastic growths, such as fibromata, sarcomata, and endotheliomata, and those of epithelial or epiblastic origin, such as carcinomata.

Carcinomatous growths may be subdivided into those springing from the superficial epithelial cells of the cutis and those of deeper origin from the cellular elements of the various gland ducts.

True carcinomata grow rapidly, spread by means of the lymph channels, and at an early stage invade neighbouring lymphatic glands, whereas a rodent ulcer progresses very slowly and exhibits hardly any tendency to invade adjacent glands.

Benign Growths.—(*a*) *Fibromata* show a special predilection to grow from the connective-tissue of the lobule, and as a rule owe their origin to irritation produced by piercing the ear for the wearing of ear-rings or other such ornaments.[1] They are frequently bilateral and symmetrical. They present as rounded, smooth, or lobulated tumours of varying size, colour, and consistence, and attain at times such dimensions as to produce a most unsightly deformity. They are essentially benign growths and rarely recur after removal.

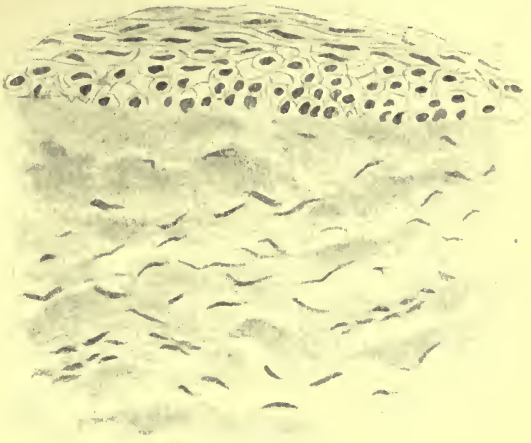

FIG. 59.—Keloid of auricle. Obj. ⅙ in.

Pathology.—There are two distinct forms of fibromata, the soft and the hard.

The soft variety often attains an enormous size and consists of elongated fusiform cells embedded in a homogeneous matrix.

The hard form is generally smaller, irregular in shape, often multiple, and consists of closely packed fusiform cells arranged in interlacing bundles with but scanty matrix (Fig. 59). It is decidedly keloid in character and is associated with a history of traumatism.

Neither variety is very vascular, the hard form showing but few thin-walled vessels.

Treatment.—If pedunculated they should be removed with a sharp pair of scissors, the raw surface produced being dressed with some simple ointment. If non-pedunculated they are best excised by means of a V-shaped incision, the edges being subsequently carefully brought together and sutured with horse hair or ophthalmic cat-gut.

(*b*) **Papillomata.**—Papillomata may grow from any portion of the cutaneous covering of the external ear or lining of the auditory meatus

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[1] *Trans. Otol. Soc.*, 1905, vol. vi. p. 66.

(Fig. 60). They are usually met with around its orifice and vary in size from that of an ordinary wart to pedunculated growths of from a quarter to three-quarters of an inch in length. At times they present a dentate or fimbriated appearance, at other times an irregular conical shape. In consistence they may be soft or hard. In a case coming under the writer's care the growth which sprang from the internal surface of the tragus measured three-quarters of an inch in length and possessed a hard indurated base. In another case the outer orifice of the auditory meatus was completely filled by a moriform growth one-half inch in length springing from the centre of its posterior wall.

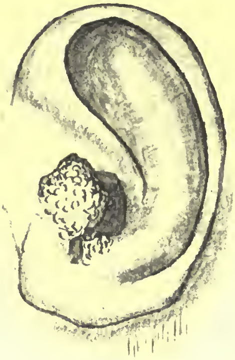
Fig. 60.—Papilloma of meatus.

Treatment.—The growth should be clipped off with a sharp pair of curved scissors and the raw surface touched with chromic acid. Warts should either be cut away in a similar manner or destroyed by the local application of acid nitrate of mercury, sozoiodol of mercury, or carbonic acid snow.

(*c*) **Angiomata.**—Angiomata are comparatively rare. They are most frequently situated in or near the meatus, occasionally upon the posterior surface of the auricle (Fig. 62). They are occasionally congenital, at other times the result of some form of trauma. In size they vary greatly, at times being little larger than the head of a pin, at other times forming large and almost pendulous tumours. The colour of the growth varies from reddish pink to deep blue. It is as a rule soft, and if pressure be kept up for any length of time is capable of being emptied of all the blood which it contains.

Angiomata may be developed on the type of either blood or lymph vessels, the difference residing chiefly in the thickness of their walls and their contents.

All vascular tumours are more or less mixed with varieties of connective-tissue, so that it would be more correct to describe them as angio-fibromata, angio-lipomata, angio-myomata, angio-sarcomata, etc., according to the prevailing supplemental tissue. A pure angioma is very rare. One of the commonest situations is on the floor of the cartilaginous meatus, where they often become ulcerated from irritation. Many of them, doubtless in connection with granulomatous tissue in which the vascular elements are in excess after the suppurative process is past, constitute innocent neoplasms. But should irritation continue from the presence of a discharge sarcomatous degeneration may result.

Histologically they consist of irregular vascular channels surrounded by a varying amount of connective-tissue, fibrotic or myxomatous (Fig. 63). The walls are formed of fibroblasts and are lined with a single layer of endothelium. The lymph type are markedly attenuated, being merely a network of spaces lined with endothelium.

Having no muscular elements, they bleed freely on removal or as the result of trauma.

The sarcomatous variety is generally developed upon the type of an endothelioma, the chief cells being fusiform with large oval nuclei, and showing a tendency to alveolar grouping. Occasionally the ordinary types of small spindle cells are seen and are difficult to distinguish from young fibromata.

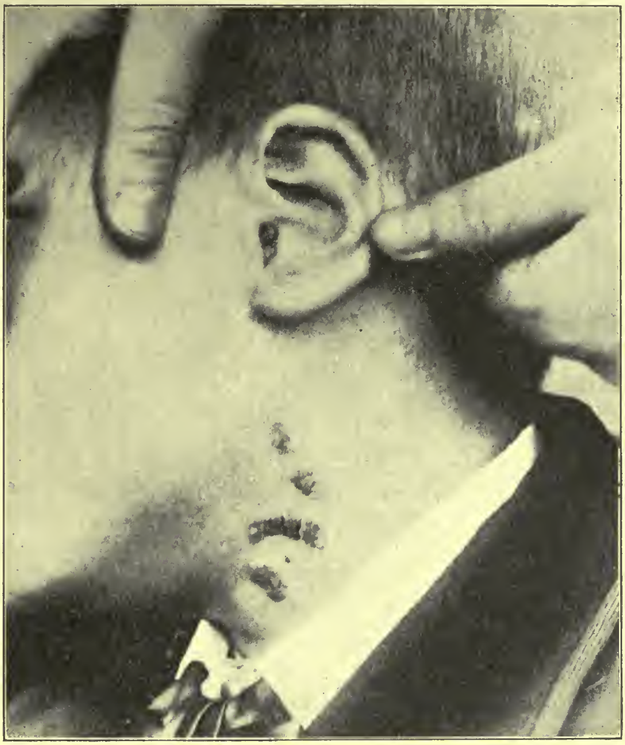

FIG. 61.—Cervical branchial fistulae with meatal papillomata (probably infective).

Lymph-angiomata and angio-lipomata occur most frequently on the auricle and may assume large dimensions.

Symptoms.—Apart from the very obvious deformity to which they give rise, angiomata produce no symptoms of importance other than obstructive when meatal in situation. In those cases where rapid growth takes place pain may be complained of owing to sudden stretching of the skin. In large cavernous angiomata a disagreeable sense of pulsation is at times complained of.

Treatment.—If of small size, very vascular and non-pedunculated, their removal is at times satisfactorily effected by means of electrolysis, the platinum needle attached to the negative pole of the battery being thrust through the base of the growth and a current of from 5 to 8 milliamperes passed until the skin surrounding the point of puncture becomes blanched. Repeated punctures are made until the whole growth has been traversed and destroyed. Sloughing results with ultimate healing by granulation.

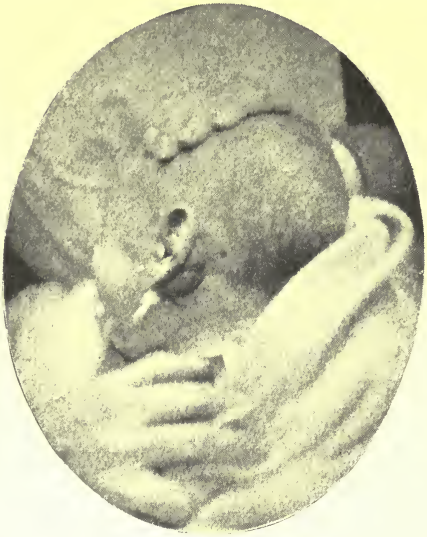

Fig. 62.—Naevoid angioma of auricle.

Or the mass may be punctured in various places with a minute cautery point or with a sharp needle heated to a bright red heat.

In the case of a large angiomatous mass occupying the posterior surface of the auricle the writer ligatured the posterior auricular artery with satisfactory results.

The injection of perchloride of iron or of other medicaments is inadvisable on account of the risk of the fluid employed or clot entering the general circulation.

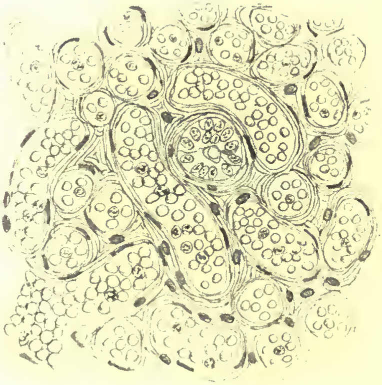

Fig. 63.—Naevoid angioma of auricle and meatus. Obj. ⅙ in.

In the case of a pedunculated angioma growing from the free margin of the helix the writer obtained a successful result by ligature of its pedicle.

When occurring in the meatus, reflection of the auricle may be necessary, followed by complete excision.

(*d*) **Osteo-chondromata,** chondromata, and chondromyxomatous growths present as hard circumscribed slowly growing and, as a rule, painless tumours (Fig. 64). In a few recorded cases they have attained considerable size and have produced marked deformity.

True bony growths, osteomata, have also been met with springing from the outer surface of the pars mastoidea and from the posterior osseous wall of the meatus. They may be movable or fixed. In a case recorded by Weinlechner[1] the growth attained the size of a hen's egg.

6. **Malignant Disease of the Auricle.**—Malignant disease of the external ear occurs in the carcinomatous, endotheliomatous, and sarcomatous forms. The former is the more frequent and is usually of the squamous-celled type.

According to Zeroni[2] the free margin of the helix and the upper portion of the auricle are the parts most frequently implicated, and this he explains as being due to their exposed situation and to the fact that in this region senile degeneration of epithelial cells is most prone to take place (Fig. 65).

In an analysis of 16 cases seen and examined microscopically by the authors, the free margin of the helix was primarily involved in 5, in 8 the ulcerative process started in the external auditory meatus, in 3 cases from its depths, and in 5 from just inside its entrance, in 2 cases from the angle formed by the attachment of the auricle with the side of the head, and in 1 case in a cicatrix running across the auricle at the junction of its upper and middle thirds. 10 of the patients were males, 6 were females. The youngest patient was aged twenty-seven, and the oldest seventy-three.

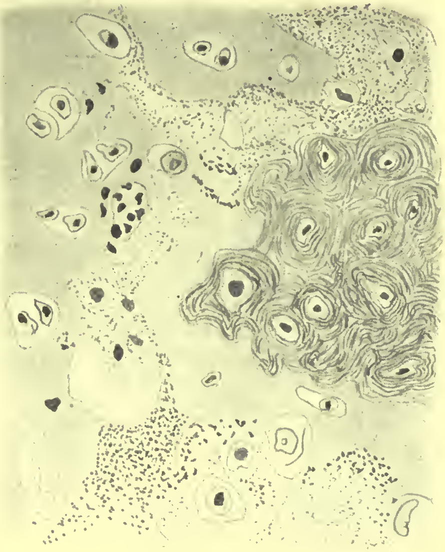

FIG. 64.—Primary osteo-chondroma of meatus. Obj. $\frac{1}{8}$ in.

In 1 case the disease was said to have started from an attack of furunculosis of the meatus, and in 4 cases to have followed chronic middle-ear suppuration.

Injury, frost-bite, sebaceous plugging, and the presence of scar tissue act as predisposing causes.

In the earliest stages of an epithelioma of the auricle a hard indurated nodule forms, tender to touch, and accompanied by neuralgic pains especially severe at night. After a varying interval the nodule breaks down and forms an irregular ulcer with indurated edges from whose surface a thin sanious and often foetid discharge exudes. As the outcome of

[1] *Monatschr. f. Ohrenheilk.*, 1887.

[2] *Archiv f. Ohrenheilk.* Bd. xlviii.

progressive ulceration the cartilaginous framework of the external ear becomes involved and frequently perforated.

In a record of 13 cases Heil[1] found but two instances in which the cartilage remained normal.

The progress of the ulcerative process is very rapid and may involve the tympanic cavity and the tissues of the side of the head, and even penetrate the cranial bones, exposing the meninges. In such rapidly advancing carcinomata glandular enlargement is met with at a comparatively early stage, and at times assumes enormous proportions.

Enlargement of adjoining glands is largely dependent upon the presence or absence of ulceration of the original growth. When ulceration has taken place, and where consequently a septic process is superadded, rapid involvement of glands is prone to occur.

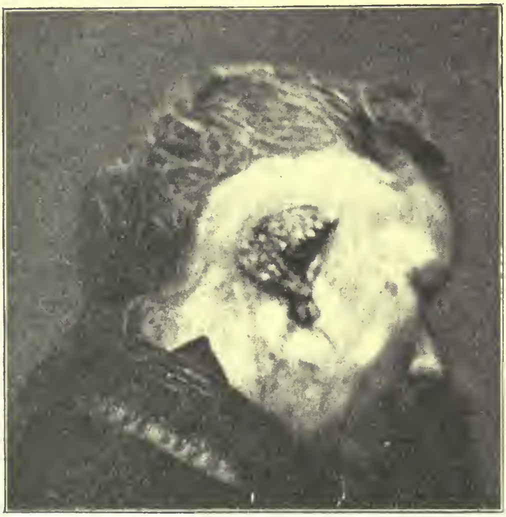

Fig. 65.—Epithelioma of auricle and meatus. Patient aet. 66.

In a case seen by the author where the disease had originated in the right concha, extension took place along the auditory meatus to the tympanum and ultimately to the internal ear. Enormous glandular enlargement resulted, the patient subsequently dying from sudden and profuse haemorrhage from exposure and ulceration of the internal carotid artery.

(*a*) Epithelioma of the auricle must be carefully differentiated from rodent ulceration, from noma, and from tuberculous and syphilitic ulcerative processes.

Rodent ulceration may occur primarily upon the auricle, but is usually the result of extension from adjoining parts. Noma is a rare disease (p. 91), and is characterised by gangrenous ulceration, by rapid and extensive destruction of tissue, and by symptoms of acute septic intoxication.

Syphilitic and tuberculous ulceration is also rare. In the former the history of the case and the sharply defined and punched-out character of the ulceration is diagnostic; in the latter the shallow ulceration covered with a thin sanious and foetid secretion, and the fact that scrapings from the ulcerated surface may, though rarely, show tubercle bacilli, afford strong evidence of the true nature of the disease; still it is more satisfactory to examine an excised fragment of tissue.

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[1] *Inaug. Dissertation*, Göttingen, 1897.

Treatment.—The treatment of malignant disease of the auricle must be regulated by the extent, position, and exact histological structure of the growth. In cases of skin-epitheliomata or rodent ulcer the application of Röntgen rays or radium has been attended by good results, and is well worth trying, as if successful the cosmetic result is excellent and the scarring very slight. Should no improvement be noticeable after the fourth or fifth sitting, the treatment should be given up and resort at once had to surgical interference.

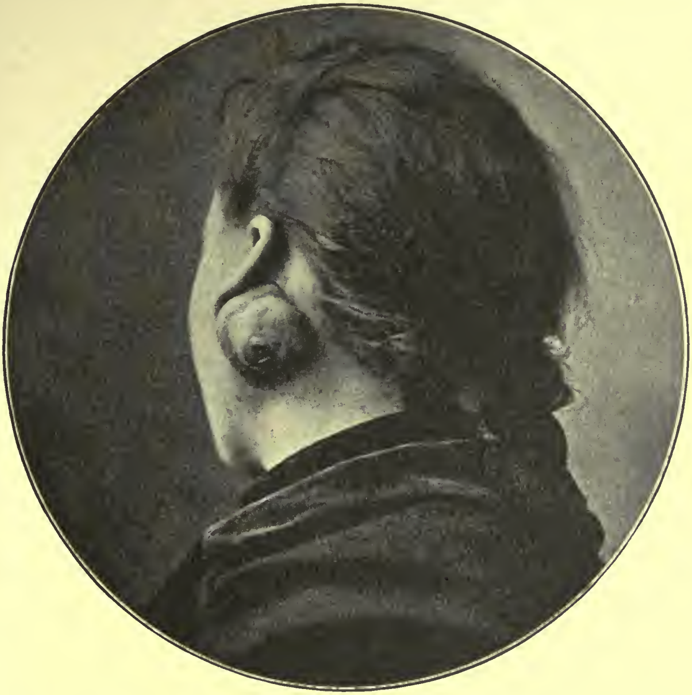

Fig. 66.—Squamous-celled carcinoma arising from skin over mastoid process and involving the posterior surface of auricle.

Improvement is indicated subjectively by a diminution in the amount of pain, and objectively by a softening of the indurated edges of the ulcer, by the formation of healthy-looking granulations, and by a creeping in of epithelium from its periphery. The more deeply seated carcinomata are not so well adapted for treatment by light therapy, the penetration of the rays extending only to a depth of about 5 millimetres. Under such circumstances free ablation of all diseased tissue is called for.

Where the greater part of the auricle but not the auditory meatus is involved amputation of the whole external ear is advisable. In such cases an artificial ear with special spring attachments may subsequently be worn.

In certain cases surgical interference combined with the application of Röntgen rays is beneficial.

In inoperable cases dusting the ulcerated areas with orthoform and resorcin powder relieves pain.

Resort has frequently, however, to be had to morphia at a comparatively early stage of the disease.

Recurrence is extremely prone to take place either at site or in adjacent glands.

(*b*) **Sarcomatous** growths springing from the connective tissues of the auricle or external auditory meatus are rare. They tend to run a more or less rapid course, and present much the same malignant characteristics as do carcinomata, their rate of growth being if anything more rapid and dependent to a large extent upon their structure, round-celled sarcomata growing much more rapidly than spindle-celled or fibro-sarcomata. Involvement of the periotic glands is a comparatively late symptom. Instances of mixed sarcomatous growths, *e.g.* osteosarcomata, angiosarcomata, and chondro-sarcomata, are on record.

(*c*) **Endotheliomata.**—Comparatively few cases of endothelioma have been recorded hitherto, but our experience, however, shows that they are by no means rare in connection with the deeper parts of the auditory apparatus. In a case recently under the care of one of us[1] the growth appeared (Fig. 67) in the form of a large pedunculated papilloma springing from the posterior margin of the cutaneous auditory meatus. The microscopic report, as supplied by Mr. J. H. Targett, was as follows :—"This tumour has the general structure of a warty papilloma of the skin, the processes of which are infiltrated with a new growth while the subjacent tissues are much inflamed. The new growth involves the corium and its prolongations into the papillae, some of which are greatly thickened by it. The cutis vera, though in close contact with the growth in many places, is not affected by it. Histologically the younger parts of this neoplasm are composed of rounded alveoli filled with several cells having

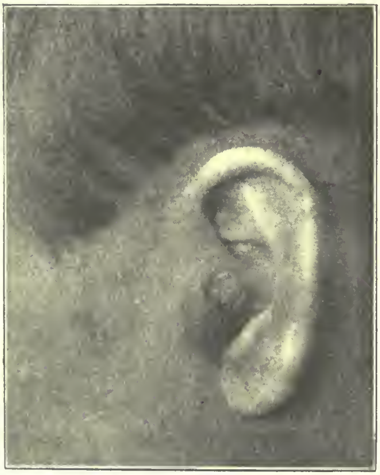

FIG. 67.—Endothelioma arising from the margin of the external auditory meatus.

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[1] *Proceedings of the Royal Society of Medicine*, vol. iii. No. 6, April 1910.

an oval nucleus. In the other parts of the tumour all trace of alveolation is lost, and the whole papilla is occupied by closely packed cells. The alveolation where most distinct is formed by a single layer of flattened cells like endothelium, and apparently there is no connective tissue proliferation in the growth."

In this case the growth was derived from the lymphatic vessels of the corium and papillae. Records of other cases are to be found in the *Transactions of the Otological Society.*[1]

7. **Gouty Deposits.**—In gouty subjects tophi or deposits of urate of soda are frequently found upon the free margin of the helix or within the substance of the lobule. As a rule these deposits occur bilaterally and symmetrically.

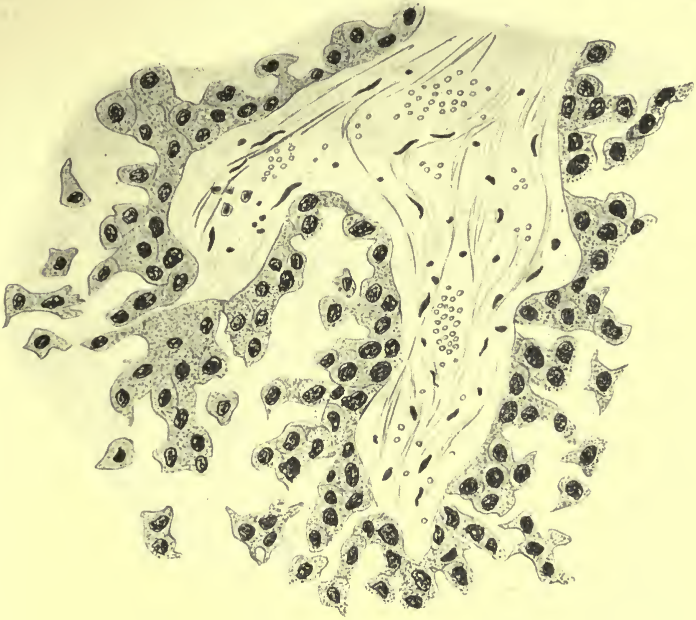

FIG. 68.—Endothelioma of meatus. Obj. $\frac{1}{12}$ in.

In size they vary from that of a millet seed to that of a small pea. The superimposed integument appears stretched and presents a dry white and glistening appearance. At times ulceration takes place, followed by the spontaneous escape of the tophus.

Pathology.—Tophi occur in two distinct forms, glandular accumulations and interstitial infiltrations or deposits.

In either case the salt which is deposited may be the urate of soda or the urate of lime—crystalline or amorphous. There is usually some evidence of a slight inflammatory process in the surrounding tissues.

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[1] Vol. i. p. 30; ii. 130; iii. 12, 57; iv. 11, 17, 88; vi. 44.

When sebaceous glands are affected there is considerable distension of their acini by a mixture of laminated cells and amorphous granules very closely packed together.

The walls of the acini and gland-ducts are thickened and surrounded by sclerosis often infiltrated with salts, but remain free from any adhesion to the underlying cartilage.

In the interstitial infiltrations islands of crystalline and amorphous deposit are found in the deeper subcutaneous tissue and in the perichondrium, but present the appearance of being superficial. These nodules, after decalcification, exhibit blocking and distortion of blood-vessels with a varying amount of lymphocytic and fibrous deposit. Sometimes they occupy actual depressions in the cartilage, whilst later on the skin covering them becomes attenuated and often eczematous.

Treatment.—Attention to diet, exercise, the state of the skin and excretory functions is indicated. The internal administration of alkaline drugs and saline aperients is beneficial.

In those cases where their presence produces an unsightly deformity or causes severe pain their removal may be called for.

8. **Hyperaemia.**—Hyperaemia of the auricle may be active or passive. The chief causes of active hyperaemia are exposure to heat or cold (frost-bite), mechanical irritation, or injury. It may also result from an acute attack of eczema or erysipelas or as part of a general cutaneous erythema.

Passive hyperaemia is met with in cases of advanced cardiac disease, in cirrhosis of the liver, in chronic alcoholism, and when from any cause the venous flow from the vessels of the head is interfered with.

In certain cases of disease of the sympathetic nervous system and in various forms of neurosis a distinct and usually unilateral hyperaemia of the auricle is at times noted. This form of angio-neurosis is especially common in young women and in women at about the time of the climacteric, is generally worse at night and in warm and badly ventilated rooms. When frequently recurring it is prone to lead to permanent thickening of the skin.

Hyperaemia of the cutaneous lining of the auditory meatus, more especially of its osseous segment, is seen in cases of acute otitis media, in mastoiditis, and as a sequel to diffuse otitis externa, eczema, and furunculosis. It is also met with in cases of inflammation of the parotid gland and after the removal of foreign bodies, more especially when considerable difficulty has been experienced in their extraction.

When hyperaemia lasts for any considerable time the ceruminous and sebaceous glands become excessively active, and exude large quantities of secretion which tends to occlude the meatus.

The subsidence of hyperaemia is followed by desquamation.

Treatment.—The application of lead lotion or Goulard's lotion to the hyperaemic areas is followed by marked relief. Pieces of lint soaked in lotion should be applied to the auricle, covered with india-rubber tissue and retained in position by a bandage or suitable ear-pad. Smearing the auricle with subacetate of zinc or lead ointment or hazeline cream, or dusting it lightly with some such cooling powder as oxide of zinc or acetate of lead, is also efficacious.

In those cases of hyperaemia due to lesions of the sympathetic system galvanism is indicated, with, in addition, the avoidance of over-heated rooms, tea, coffee, and alcohol. In severe cases change of air to some mountain resort and the administration of nerve tonics is called for.

In hyperaemia of the auditory meatus the particular cause responsible for its production should be sought for and suitably treated.

9. **Dermatitis of the Auricle.**—Dermatitis of the auricle may vary in intensity from a mild erythema of the cutis to a severe form of gangrenous inflammation. It is, as a rule, due to exposure to severe heat or extreme cold, or to some form of trauma, such as a blow or fall upon the ear, an insect bite, a burn, scalding, piercing the lobule for ear-rings, or the wearing of too heavy ear-rings.

As the result of the inflammatory process the auricle becomes red and swollen, and stands out slightly from the side of the head. A feeling of fulness and dragging weight may be complained of. In mild cases the disease runs a short and rapid course, followed by complete recovery. In cases of a gangrenous type severe constitutional symptoms are induced, while recovery may take place with marked deformity of the auricle.

Treatment.—Rest in bed and avoidance of exposure is called for. Locally the application of a sedative lotion, *e.g.* Goulard's, or the smearing of the skin with acetate of lead or ichthyol ointment, is advisable. In severe cases after having found the causal organism the subcutaneous injection of an autogenous vaccine is indicated.

Prognosis.—The prognosis is good, complete resolution taking place within from six to ten days, except in cases due to the poisonous stings of certain insects, *e.g.* wasps, horse-flies, etc., when the inflammatory reaction is often severe and the duration of the after-effects protracted.

10. **Erysipelas of the Auricle.**—Primary erysipelas of the auricle is a rare affection. In most cases the inflammatory process spreads from the tissues of the head and neck to the auricle, invading at times the auditory meatus and in exceptional cases attacking the middle ear. The presence of excoriations or abrasions of the skin, eczema, fissures, and various forms of injury predispose to its occurrence, the various bacilli gaining an entrance through the broken cutis.

Pathology.—Erysipelas of the auricle is a cellulitis set up by a pyogenic organism, generally the result of trauma or by extension from disease of adjacent parts. It is characterised by rapid hyperaemia of the loose cellular tissue, or the deeper perichondrium, when it is difficult to distinguish from perichondritis. It, however, rapidly spreads with swelling and oedema. The blood-vessels become distended and blocked by coagulated blood, while the lymph channels, both interstitial and perivascular, are filled with wandering leucocytes. The process may at this point cease or become suppurative, when pus is found in the distended connective tissue, whose fibres and cells are killed and dissolved by trypsin derived from dead leucocytes.

Various bacteria have been found, the most prominent being *streptococcus longus* and *brevis*, *diplococcus pneumoniae*, Gram – *diplococci*, *staphylococcus albus*, *cereus*, and *aureus*. In infants the *gonococcus* has been seen by us and the *bacillus coli communis*.

Symptoms.—The disease is ushered in by severe pain and tenderness in the affected region, by a rapid rise of temperature, and by swelling of the surrounding glands. In severe cases the auricle becomes greatly swollen, its normal contour obliterated, and its cutaneous covering dry, glazed, and stretched. Occasionally bullae form upon its surface, which after a short existence rupture and discharge a clear serous fluid.

Small abscesses, which tend to undermine the cutis and which may in exceptional cases lead to infection of the perichondrium, are at times met with. A feeling of fulness and heaviness upon the affected side of the head, accompanied by a sensation of vertigo, is occasionally complained of. The inflammatory process may last for a few days, and then rapidly subside, or may spread over the head and face and in exceptional cases over the body. Gangrene of the auricle has been known to result from an acute attack of erysipelas.

In three cases of severe erysipelas of the auricle occurring during the course of a septic otitis media the writer noted a very rapid and complete healing of the middle-ear disease after the erysipelas had run its course.

Treatment.—Immediate isolation of the patient is necessary. To relieve pain and to reduce fever antipyretics and sedatives are called for. Locally the infected area should be dusted with boracic acid or painted with ichthyol or resorcin collodion, and covered with a pad of Gamgee tissue.

Painting the affected area with a 5 per cent solution of persulphate of iron is useful, as is also the application of lint soaked in a warm solution of acetate of lead or aluminium. Immediate drainage should be effected in those cases where abscess formation takes place.

In severe cases the injection of anti-streptococcic serum has been successfully employed.

Suppurative conditions of the middle ear demand treatment upon ordinary principles (p. 231).

The internal administration of perchloride of iron and chlorate of potash is beneficial, followed by change of air and a course of tonics.

11. **Noma.**—Noma is a form of gangrenous ulceration which attacks the auricle, the fibro-cartilaginous meatus, and the soft tissues in the immediate neighbourhood of the external ear. It is met with, as a rule, in poorly nourished and cachectic children, runs a rapid course, and in almost all cases ends fatally.

The rapidly spreading ulceration may extend superficially or invade the tissues deeply, involving the mastoid process or the parotid gland and soft tissues of the cheeks. In many cases infection is due to an already existing otitis media purulenta.

The course of the disease is rapid, and death results from acute septic intoxication or asthenia.

Pathology.—Noma commences as a greyish slough, with indurated edges at or near the orifice of the meatus and associated with intense pain. At first it remains for several weeks as an indolent ulcer, with but slight discharge, somewhat resembling a slough following the application of an escharotic. It soon extends rapidly with brawny infiltration but with slight evidence of granulations, destroying the auricle and adjacent soft tissues and exposing the bone, which is grey and dry. The discharge is foetid and thin, containing large mono- and multi-nucleated leucocytes, a few lymphocytes and endothelial cells, all showing marked granular degeneration with nuclear fragmentation. The infection is generally polymicrobic, such organisms as *staphylococci*, *bacillus proteus vulgaris*, *bacillus pyocyaneus*, *spirochaeta refringens*, *bacillus smaragdinus foetidus* being present.

One special variety is well marked, viz. a large Gram – diplo-bacillus, which was readily isolated from agar cultures by the writer. It closely resembled the bacillus of Friedlander. It was non-mobile, but its growth on agar was distinctly foetid.

Although its specificity has not been proved by the normal postulates, records of a bacillus having similar morphological and tinctorial characters have been reported in other cases.

As already mentioned, the essential character of the disease is a spreading gangrene or necrobiosis, but its course may be attended by the formation of granulation tissue, a protective measure which may for a time mask its true nature, and suggest a tuberculomatous process. As a rule the progress of the disease is rapid by extension to deep vessels causing septic thrombosis and death from profound septicaemia. Such occurred in the writer's case, that of a badly-nourished man aged forty-eight (a stableman), who was first thought to be suffering from glanders, as the nose was involved when first seen during the stage of apparent quiescence. The disease lasted about eighteen months in all, and the last feature was extensive thrombosis of the jugular vein, apparently starting from the sigmoid sinus. The characteristic bacilli were present during the whole period of observation (seven months), and were found also in the thrombosed jugular after death. There was no history of syphilis, but the patient, although young, was a confirmed alcoholic subject.

Treatment.—Locally the gangrenous area should be cauterised with the galvano-cautery, or with acid nitrate of mercury,[1] and covered with an antiseptic ointment, whilst tonics and stimulants should be freely administered. In addition, Sondermann's suction apparatus may be employed to draw lymph to the surface, or the affected parts dressed with Wright's hypertonic saline solution.

The subcutaneous injection of an auto-vaccine derived from a culture of the diplo-bacillus or of the mixed organisms may also be tried.

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Phagedaenic ulceration or *pemphigus gangrenosus* occurs in badly nourished and cachectic individuals, and is said to occur fairly frequently amongst the poorer classes in Ireland.

The application of nitrate of silver and antiseptic dressing of the ulcerated areas, combined with fresh air and a generous diet, is indicated.

12. **Hyperaesthesia and Anaesthesia of the Auricle and External Auditory Meatus.**—*Hyperaesthesia* may occur as the relic of some previous trauma or inflammatory process, or as the result of frost-bite, eczema, aspergillosis, or neurosis.

It is induced in some individuals by cold draughts of air, in passing from a hot to a cold room and *vice versa*, by motoring, railway travelling, etc. It occurs also as part of a general cutaneous hyperaesthesia, especially in highly strung and neurotic women. The writer has also observed it as a symptom during the climacteric. It is also due to a gouty diathesis, to gastro-intestinal reflexes, to hysteria, and to neurasthenia.

Treatment.—In hysterical individuals attention should be directed to the state of the general health and anti-spasmodics given internally. Local applications, *e.g.* friction, the inunction of lanoline ointment, and the employment of the faradic current, are at times useful.

The application of pure menthol is also at times attended by marked relief.

The wearing of a pledget of wool in the meatus is said by some patients to afford relief.

The internal administration of iodide of potassium and the inunction of mercurial ointment is beneficial when due to some gross organic nerve lesion, especially if of syphilitic origin.

If due to some gastro-intestinal reflex or to gout, suitable medicinal treatment should be prescribed.

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[1] Hutchinson, *Med. Times Gazette*, 1881.

Anaesthesia of the auricle occurs as part of a general cutaneous anaesthesia, especially in hysterical girls, in certain affections of the fifth cranial nerve, in certain cases of cerebral disease, and after loud concussions.

13. **Eczema of the External Ear.**—Eczema of the external ear occurs either as a primary affection, or in association with a general eczema of the head and other parts of the body. It may run an acute, subacute, or chronic course, and at times leads to marked thickening of tissue with subsequent deformity. It is prone to occur in poorly nourished, strumous, and rickety children, among those suffering from *pediculosis capitis*, in gouty subjects, and as the result of prolonged suppurative middle ear disease. The continuous use of poultices or fomentations, the application of irritants such as chloroform, camphorated oil, etc., the use of iodoform or iodoform dressings, and various forms of mechanical irritation, *e.g.* heat (*eczema solare*), lying upon hard pillows, the abuse of the cold water douche, etc., are also responsible for its incidence. At times it occurs without any assignable cause.

There are many habits or customs in all grades of society whose employment is often intentionally withheld from the surgeon's knowledge by the patient. Common amongst these are the introduction into the ear of fat, bacon, soaked figs, boiled onions, and tobacco for both real and imaginary aural troubles. One most pernicious custom, especially found amongst shooters, bathers, and motorists, is wearing sheep's wool or cotton wool in the ear. The former is perhaps the worse of the two, for it is not only mechanically very irritating, but is invariably highly septic. Unfortunately, wool in the ear is the first and often the only treatment which an aural discharge receives from the amateur, and still more unfortunately is permitted by the practitioner in conjunction with instillations so affording every opportunity for the successful culture of all varieties of bacteria pathogenic and non-pathogenic. Many cases of meatal eczema can be traced to such sources.

Looped-spectacle frames by their irritation are often responsible for retro-auricular eczema when combined with infection. Further, one must not overlook the part played by digital infection, particularly in children, since an eczema of the ear is often associated with intertrigo in remote parts of the body.

Eczema of the auricle is peculiarly liable to acute exacerbations, and is frequently associated with seborrhoea of the meatus.

Acute eczema is found to attack the auricle, the external auditory meatus, or the whole of the external ear. Prior to the appearance of any eruption the skin of the implicated area becomes highly inflamed, red, and swollen. This is followed by the appearance of a vesicular eruption located as a rule upon the posterior surface of the auricle, the retro-auricular groove, and the lobule. Vesicles are rarely seen in the auditory meatus or upon the outer surface of the membrana tympani.

In young children the appearance of the eruption is ushered in by a varying degree of pain, fever, and malaise. The great irritability of the skin causes the patient to scratch the part, with the result that extensive raw surfaces are produced which at times bleed freely.

In the course of a few days these raw surfaces suppurate, and become covered with adherent crusts, under which exudation of a thin irritating fluid takes place (Plate I. Fig. 3; see p. 67). In more acute attacks pustules of varying size form at an early stage of the disease ushered in by severe febrile symptoms. Should the external meatus be involved, obstructive deafness ensues, and at times tinnitus is prone to occur on account of the swelling and oedema of its walls, and impaction from accumulation of inspissated pus and desquamated epithelium.

In many of the milder cases resolution sets in two or three days after the appearance of the vesicular eruption, followed by desquamation and complete healing.

In other cases, however, weeks may elapse before exudation and crust formation cease.

As the intensity of the inflammatory process subsides a fresh layer of epithelium forms under cover of the adherent crusts, creeps gradually over the raw surfaces, and so brings the inflammatory process to an end.

Relapses are, however, not uncommon, especially in those cases where the actual and exciting cause has not been removed, since staphylococci and streptococci may remain embedded in the scales for very long periods.

In its early stages acute eczema of the auricle may be mistaken for erysipelas.

In young, ill-nourished, ill-kept, and unhealthy children, and especially amongst those suffering from *pediculosis capitis*, or eczema of the scalp and face, a subacute form of eczema is frequently met with. The formation of crusts and scabs takes place mainly in the retro-auricular groove, and in the depressions and convexities of the external ear. The irritation produced is so great that enlargement of post-auricular and cervical glands is not uncommon, ending at times in their suppuration.

In exceptional instances a mild systemic disturbance is induced as the result of absorption of toxines from underneath thick and adherent crusts.

Chronic Eczema.—Chronic eczema of the auricle is characterised by changes not only in the cutis itself but in its subcuticular connective tissue, and, as a consequence, by ultimate thickening and rigidity. The hyperplasia may become so great as to cause the auricle to stand out prominently from the side of the head, to obliterate its normal contour, and to narrow the auditory meatus. In certain cases the great increase in the connective-tissue elements of the part causes such overgrowth and enlargement as to constitute elephantiasis of the organ. Certain circulatory changes are thereby induced resulting in an oedema, the outcome of combined venous and lymph stasis. In addition, the formation of crusts is excessive, and this in conjunction with the existing fibrous hyperplasia serves to entirely alter its appearance. In consequence also of the stretching and distension of the skin, fissures result. These fissures, which cause considerable pain and discomfort, occur for the most part in the retro-auricular groove at the junction of the upper part of the auricle with the side of the head and in the fossa helicis. A serous or purulent exudate is secreted under cover of crusts and desquamated epithelium, and serves to prolong the irritation and to infect adjacent areas of healthy skin.

In many cases a dry and scaly form of eczema, characterised by the formation of thick indurated scales and associated as a rule with eczema of the scalp, attacks the auricle. The two processes—the crusty form of eczema and the scaly—may co-exist at one and the same time, or the one may follow the other.

In the less severe type of case the inflammatory process may subside spontaneously, whilst in those of marked severity, after a more or less prolonged course of treatment, resolution may be effected, a varying degree of rigidity and induration of a previously pliable auricle remaining. The existing stenosis of the meatus, so common in severe and chronic cases, leads to retention and impaction of inflammatory products, with resulting impairment of hearing and tinnitus.

Secondary changes may also take place in the dermic layer of the membrana tympani leading to its permanent thickening.

Pathology.—On the external ear as elsewhere eczema occurs in many forms and degrees which vary with the nature of the infecting organism, the area affected, and the duration of the process. It may be moist or dry, acute or chronic, painful or painless, unilateral or bilateral, and it may occur in those who are apparently in the enjoyment of perfect health.

When confined to the meatus and concha it is most likely due to middle-ear disease, but not necessarily so, since in uncomplicated otomycosis there is almost invariably some coincidental eczema; in fact, the aspergillus is often responsible for its chronicity. Again, too, there is a dry form which is primarily meatal in origin characterised by squamal accumulations on an inflamed cutis (*eczema rubrum*) in which a great many forms of bacteria are found.

To arbitrarily ascribe any relative or actual responsibility to any one bacterium is somewhat difficult in view of the many varieties which occur in the chronic types. But in acute eczema, although bacteria may be numerous, the varieties are few.

In eczema following middle-ear disease the writer has found a Gram – diplococcus similar to, if not identical with, the diplococcus catarrhalis in a large proportion of cases accompanied by *bacillus proteus vulgaris*, *bacillus subtilis*, *bacillus butyricus*, and torulae in varying proportions.

In *red* eczema (*eczema rubrum*), such as occurs in children and feeble adolescents, a streptococcus is most frequently found, while in the follicular variety *staphylococcus aureus* has been recorded by many observers.

The *staphylococcus albus epidermatis* and Unna's *bottle bacillus* are associated with the seborrhoeic form.

In chronic forms the following micro-organisms are often very numerous in addition to those already mentioned—*bacillus proteus vulgaris, bacillus butyricus, torulae, penicillium glaucum.*

The writer has seen two cases of chronic eczema of the meatus, in which he found swarms of *acarus scabiei* mingled with epidermic scales.

Symptoms.—The prominent symptoms are pain, irritation, deafness, tinnitus, and discharge. The irritation is at times so persistent as to cause the patient to employ various mechanical appliances to rub and scratch the part, with the result that healthy areas of skin become infected.

Deafness and tinnitus when present are due either to mechanical obstruction of the meatus or to hyperaemia of the middle or internal ear.

Co-existing inflammation of the Eustachian tube and tympanic mucous membrane has also been observed in these cases.

Prognosis.—The prognosis varies with the severity of the case. In mild attacks of chronic eczema, without marked hyperplasia and thickening of the auricle, resolution and recovery is usual. In more severe and advanced cases, even if temporarily cured, relapses are common.

In the most severe type permanent deformity of the auricle and stenosis of the meatus is invariable. A varying amount of permanent deafness is also not unusual.

Treatment.—The treatment of eczema of the external ear should be regulated according to the type of eruption which is present and the particular stage of its development.

In acute cases before eruption of vesicles or pustules has taken place the intense feeling of heat and irritation may be relieved by the application of emolient and sedative ointments, or by painting with Goulard's or Burow's solution. All irritating solutions and applications should be carefully avoided, the inflamed auricle being dressed so as to even exclude the contact of air.. Cleansing the affected parts with water and syringing should be avoided as far as possible.

The appearance of vesicles or pustules is soon followed by their rupture, and by a moist scaly or crusty condition of the integument. Relief at this stage may be afforded by smearing the auricle with some emollient ointment, such as ichthyol (1 to 10), or painting it with a solution of the same drug in alcohol or paroleine (1 to 40).

Dusting with finely powdered boric acid, calomel, oxide of zinc, or subnitrate of bismuth is also efficacious.

In the treatment of chronic eczema strict attention should be paid to the state of the scalp and hair. All crusts, scabs, and adherent scales should be softened by maceration with vaseline, lanoline, soft soap, poultices, Burow's solution, or a solution of salicylic acid (5 parts) in paroleine (100 parts), and then gently brushed off with a soft camel's-hair brush. In this way their removal is easily accomplished without injuring or infecting adjacent areas of healthy skin. Forcible tearing away of crusts with forceps is to be strictly avoided.

Where the auditory meatus is blocked by an accumulation of macerated epithelium and inspissated secretion, instillations of glycerine of borax, fluid vaseline, or acetate of lead, followed by gentle syringing with warm alkaline sterilised water, is called for. The raw and inflamed surfaces thus exposed are now to be carefully dressed with ointment or dusted with powder. Various ointments are used for this purpose, such as boracic ointment (1 to 10), benzoated oxide of zinc, diachylon (Hebra), subnitrate of bismuth, or weak oleate of mercury ointment.

To produce the greatest amount of benefit, the ointment should be spread upon a clean piece of linen and applied to the auricle so as to cover all eminences and depressions; in other words, to completely envelop it.

At the end of twenty-four hours the dressing should be removed, and all crusts and scabs gently brushed off with a pledget of wool previously soaked in paroleine or olive oil.

As the inflammatory process subsides, dressings should be applied at longer and longer intervals. At the same time as the surface of the auricle is being attended to, the external meatus, after a preliminary cleansing, should be packed with a tapering cone of wool smeared with ointment.

Recently various medicated gelatines have come into favour, more especially those containing zinc and boracic acid, or Beierdorf-Unna's preparation consisting of oxide of zinc, boracic, and salicylic acid. The gelatine, used in from 5 to 10 per cent solution and applied twice daily, is carefully painted over the inflamed areas, where it sets and forms an impermeable varnish.

Delstanche's method of treatment, favourably spoken of by Politzer, consists in syringing the meatus with a warm and saturated solution of acetate of lead, and applying the same solution to all inflamed areas upon the auricle. After a thorough soaking, all crusts are gently rubbed off with a piece of soft linen. The auricle is then massaged in order to soften it, and to assist the absorption of hyperplastic tissue. Finally, all inflamed areas are washed with acetate of lead solution, and in the intervals of treatment allowed to remain exposed to the atmosphere. The application of a 3 per cent solution of nitrate of silver is useful (M'Bride).

In all chronic cases a careful search should be made for the presence of eczema elsewhere, *e.g.* buttocks, groins, axillae, etc., and attention directed to the state of the general health. The bowels should be kept open by mild alkaline aperient draughts, such as Apenta or Hunyadi Janos water taken in hot water upon an empty stomach the first thing in the morning. Diet should also be strictly regulated, excess of saccharine food being contra-indicated.

A white flesh diet, milk, milk puddings, fish, green vegetables, and celery are indicated, with a sparing admixture of red flesh. Curries, pastry, and sweet condiments are to be strictly avoided.

In anaemic, strumous, and debilitated patients iron, arsenic, and cod-liver oil are useful. The hypophosphites and the iodide or phosphate of iron may also be given with benefit.

A course of mineral waters at such spas as Harrogate, Strathpeffer, Levico, or Guben is frequently attended by the most gratifying results.

14. **Herpes Auricularis.**—Herpetic eruptions upon the auricle occur along the course of distribution of the auriculo-temporal branches of the 5th cranial nerve, the great auricular, or the ganglia belonging to these two nerves. If along the course of the former, nerve vesicles will be situated upon the anterior surface of the auricle; if along the latter, upon its posterior surface and also upon the lobule (Fig. 69).

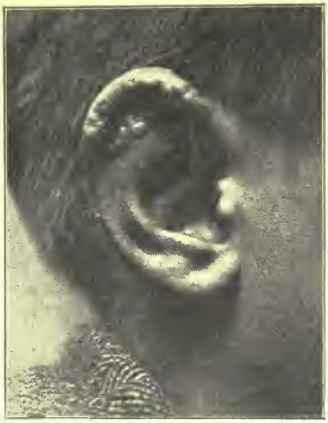
Fig. 69.—Herpes auricularis.

The geniculate ganglion, situated as it is in the course of the facial nerve at about the junction of the peripheral end of the internal auditory meatus with the commencement of the Fallopian aqueduct, and encased in the same sheath as the auditory and facial nerves, is also liable to be attacked by a specific herpetic inflammation.

Its proximity to and its intimate relationship with the facial and auditory nerves accounts for a remarkable syndrome of symptoms occasionally met with and characterised objectively by the presence of an herpetic eruption and facial palsy, and subjectively by deafness, tinnitus, nystagmus, and labyrinthine vertigo.

Four distinct types of geniculate herpetic inflammation are met with in practice.[1]

1. Herpes auricularis or herpes oticus.
2. Herpes auricularis facialis or occipito collaris with facial palsy.
3. Herpes auricularis facialis or occipito collaris with facial palsy and hypoacousis.
4. Herpes auricularis facialis or occipito collaris with facial palsy, deafness, and Ménière's symptoms.

Symptoms.—In herpes oticus the eruption occurs in the concha, external auditory meatus, and over the surface of the membrana tympani. It usually appears on the third or fourth day after the commencement of the prodromal symptoms, and disappears within from ten days to a fortnight.

In those forms complicated with facial palsy the paralysis is, as a rule, complete, and in a large percentage of cases the sense of taste over the anterior two-thirds of the tongue is involved.

When extension of inflammation has taken place to the auditory nerve a varying degree of deafness is present, and when both cochlear and vestibular branches become affected deafness and Ménière's symptoms manifest themselves.

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[1] J. Ramsay Hunt, *Archives of Otolog.*, vol. xxxvi., No. 4.

In rare instances auditory symptoms are present without the existence of facial paralysis.

After a varying interval of smarting or burning pain, often lasting for days, a number of small, glistening, white translucent vesicles, surrounded by a zone of congestion, make their appearance either singly or in groups.

In exceptional instances considerable systemic disturbance is produced, accompanied by a rise of temperature, malaise, and sleeplessness.

The appearance of the eruption is usually followed by marked remission in the intensity of local pain and discomfort.

After a few hours, or even days, the vesicles rupture and dry up, leaving no indication of their former existence.

Post-herpetic neuralgia is somewhat rare.

Pathology.—Herpetic eruptions consist in the formation of clusters of watery vesicles, each with an inflamed base and characterised by definite cycles or stages.

The vesicles may appear as solitary points or as distinct groups of inflamed papillae, over which the Malpighian cells are chiefly involved. The dermal papillae themselves exhibit marked capillary distension with but scanty migration of leucocytes in the perivascular lymph channels; but if the inflammation be more intense, or when mechanically irritated or infected, hæmorrhage and pus may result with subsequent atrophy of the papillae and slight scarring.

The chief changes are in the Malpighian cells, which rapidly swell and vacuolate, forming a clear vesicle which is at first translucent, but into which leucocytes may wander and give rise to opacity and pustulation.

Such changes involve the nuclei as well as the cytoplasm of the epithelial cells, which exhibit a striking spherical fragmentation, while as the fluid—derived partly from the cytoplasm and partly from the vessels—increases, the spaces become distended and coalesce. Turbidity is followed by crusting and healing.

Fluid from the clear vesicles rarely contains anything beyond a few granular polymorphous leucocytes, but when it is very turbid or purulent staphylococci and diplococci are frequently found. The diplococci found are of two kinds: Gram +, which are probably pneumococci; and Gram −, which morphologically correspond with those which infest the throat and nose, and which occur also in acute inflammations of the middle ear.

Although it is very tempting to attribute a causal relationship to the pneumococcal form, they are probably of surface origin.

Histological evidence of any peripheral nerve lesion is wanting, but the relation between pneumonia and herpetic eruptions has already been fully established.

Prognosis.—The prognosis is, as a rule, favourable. Occasionally it may be months before the last traces of facial palsy disappear, and in the

Ménière type of case a certain degree of deafness with tinnitus and facial paralysis may persist. After a cure has taken place hyperaemia may continue for some considerable time.

Treatment.—The main indication is to allay the severe pain usually complained of. Locally the application of glycerine of belladonna, cocaine ointment (5 per cent), or acetate of lead lotion (1 to 10) is of value. After rupture has taken place dusting with dermatol, aristol, or xeroform powder, with or without the addition of orthoform, is useful.

In exceptionally severe cases it may be necessary to give a hypodermic injection of morphia to relieve pain and to induce sleep, or several doses of acetanilide.

Tonics such as quinine, salicylate of quinine, arsenic, strychnia, or the hypophosphites are indicated along with a liberal diet, change of air, and the exhibition of stimulants.

Herpes Gangrenosus Hystericus. — Politzer has described this affection in a case in which the herpetic eruption developed upon the tragus and anti-tragus with severe attacks of pain. Healing ultimately took place with considerable deformity due to cicatrisation.

15. **Lupus.**—Lupus of the external ear may be primary or secondary. Primary lupus of the auricle is rare. As a rule the disease spreads from the meatus, face, or neck.

All varieties of lupus are met with upon the external ear, the most important from the practical point of view being *lupus vulgaris*, *lupus hypertrophicus*, and *lupus erythematosus*. If allowed to run its course unchecked, ulceration, followed by cicatricial contraction and unsightly deformity, ensues, but under efficient treatment the results obtained from modern methods of technique are surprisingly good.

Lupus nodules vary much in size. They are of a pale pink colour and extend deeply into the subcutaneous connective-tissue. Between the various nodules areas of healthy skin exist.

(*a*) **Lupus Vulgaris.**—Lupus vulgaris is the common form of lupus found attacking the external ear. It is met with, as a rule, in children and early adult life, and usually amongst those who are badly fed and clothed, and who live in insanitary, damp, and dark dwellings. It may attack any part of the auricle, but seems to prefer the edge of the meatus. Although its identification may first be made in this situation, it probably started much more deeply, so conforming to its preference for a muco-cutaneous junction.

It appears either as a smooth, dry, cicatricial area, or as a moist ulcer with thickened edges and a nodular base, spreading superficially or deeply in the subcutaneous tissue.

It is generally admitted to be of a tuberculous nature, but like many other tuberculomatous processes, the *bacillus tuberculosis* is not a striking feature of its structure. In a very long experience the writer has entirely failed to demonstrate its presence in lupus tissue from ear, nose, larynx, or pharynx. The suggestion that tuberculo-toxin rather than the bacillus itself is responsible for the lesion is certainly more in accord with histological, and, in a measure, with clinical, evidence.

Histology.—Whether of the ulcerating or non-ulcerating type lupus nodules are practically alike, consisting of masses of granulomatous tissue (Fig. 70). These are composed of closely-packed lymphocytes mingled with endothelial cells which, unlike miliary foci, do not form solid groups, but spread in all directions and become mixed with lymphocytes. In parts, however, they form strands or bundles which apparently undergo transformation into fibrous tissue. Whether this cicatricial change is due to direct transformation of the endothelial cells, or originates in fibroblasts, is uncertain. However, these endothelial elements which play such a prominent rôle in all granulomata do not, as a rule, caseate as in true tubercle, but undergo an atrophic and sclerotic change. From these elements giant cells are formed which are also a striking feature in most granulomata. In lupus they are not so numerous as in tubercle, and are less regular in size and shape. They are evidently cylindrical masses of endothelial cells formed either by fusion or by nuclear multiplication without cell division. Although the tissue is slightly vascular it is more richly supplied with blood-vessels than tubercle. It has the power of invading and replacing every kind of structure, spreading apparently by the lymphatics. In addition to lymphocytes and endothelial

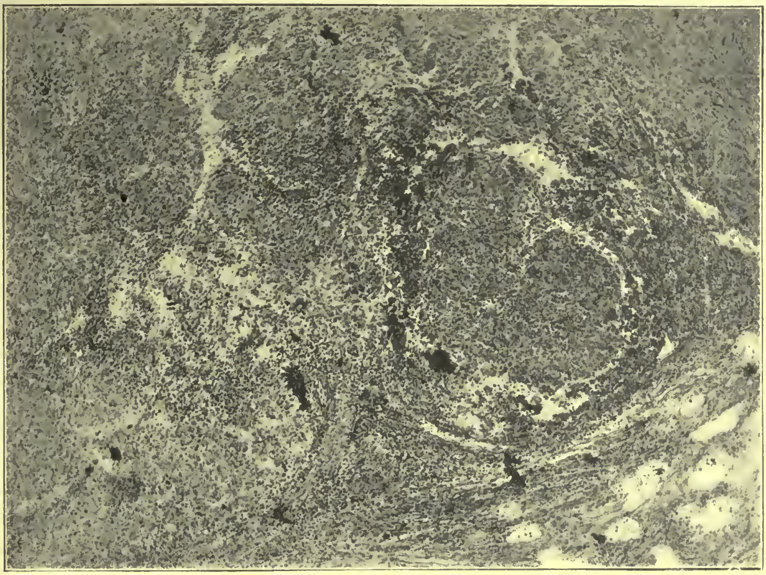
Fig. 70.—Lupus of auricle.

elements leucocytes and plasma cells are present in numbers which vary with the rate of progress, the latter being more prominent in sclerotic cases. When ulceration occurs the cutis is entirely replaced by granulomatous tissue, but returns in an attenuated form as healing progresses. More or less cicatricial deformity invariably follows.

Macroscopically it is characterised by the appearance of slightly elevated tubercles of varying size which penetrate deeply into the subcutaneous connective-tissue. Between the various nodules healthy areas of skin exist. These nodules tend to coalesce and to form small indurated areas which may be distinctly felt through the skin. Such areas may remain for long periods without almost any perceptible alteration, or they may break down and form indolent ulcers which have the peculiarity of frequently healing at one part whilst progressing at another. The ulcerative process may extend superficially (lupus superficialis) or deeply (lupus profundus). Cicatricial contraction and deformity is prone to occur, the auricle becoming at times almost unrecognisable and the auditory meatus occluded.

Diagnosis.—The presence of numerous small tubercles or nodules with intervening areas of healthy skin, or the presence of indolent ulcers with soft edges, and at times a partially cicatrised surface, combined with evidences of lupus elsewhere in the body, *e.g.* pharynx, larynx, is, as a rule, sufficient to render the diagnosis a matter of certainty.

During the stage of ulceration the disease may, however, be confounded with syphilis or carcinoma.

In *syphilis* there are invariably other manifestations present, while the ulceration is a more rapid process, is more sharply defined, and is surrounded by a zone of congestion. In *carcinoma*, which is almost invariably a disease of middle life, while lupus is a disease of childhood or early adolescence, the ulceration is more rapid, is accompanied by intense pain, and presents a sharply-defined, hard, and indurated border in contrast to the soft and flabby edge of a lupus ulcer.

In addition, in lupus more than one ulcer may appear at one and the same time; in true carcinoma there is never more than one; whilst lupus ulceration shows a tendency to cicatrise spontaneously, whereas in carcinoma progressive destruction of tissue takes place.

(*b*) **Lupus Hypertrophicus.**—Lupus hypertrophicus is characterised by an excessive growth of granulation tissue, which so frequently is found sprouting from the base of the ulcerated patches met with in cases of lupus vulgaris. As the outcome of continued suppuration infection of the perichondrium is prone to take place, with resulting cicatricial contraction and subsequent deformity.

(*c*) **Lupus Erythematosus.**—Lupus erythematosus is known to attack the auricle as well as other exposed cutaneous surfaces. It has a great tendency to be symmetrical, and is said to have exciting causes in traumatism, exposure to extremes of temperature and strong sunlight, and to occur especially in those suffering from hepatic cirrhosis, kidney disease, and anaemia.

In appearance it assumes the ordinary "butterfly patch" of the face when chronic, which is the common form; but an acute variety strongly simulates local cellulitis or erysipelas, and has much less tendency to be symmetrical.

It may be scaly or smooth, according to the depth of infiltration, and generally leaves a scar.

Both aspects of the auricle may be involved, but it specially selects the outer surface, beginning at the edge of the helix. In the acute form the tendency is to involve the tragus and meatus.

Pathology.—Lupus erythematosus occurs in connection with the auricle in two forms: (1) chronic or circumscribed, (2) acute or diffuse.

The chronic type is the commoner. It is usually symmetrical, and generally takes a superficial and cicatricial course, leaving a well-marked scar.

Each patch consists of a raised edge or border surrounding a distinctly pale concave and scaly area. Sometimes desquamation is absent when the whole area is raised, nodulated, and of a pink colour simulating lupus vulgaris.

Histologically it consists chiefly of lymphocytic infiltration of the subcutaneous tissue which, in the superficial or desquamative type, chiefly attacks the papillae, while in the non-scaly forms it spreads in the reticular or deeper layer of the dermis. Mingled with the lymphocytes are endothelial elements, less numerous than in lupus vulgaris, and rarely, if ever, any "giant cell" formations. At first the capillaries are distended, but later become obliterated, while the Malpighian cells show vacuolation and rapid keratinosis, with desquamation in the scaly variety. At a later stage atrophic sclerosis occurs with marked scarring. No tubercle bacilli have been demonstrated.

The acute, or diffuse form, bears a striking resemblance to erysipelas, being often attended by febrile symptoms. It, however, lasts longer, is sharply circumscribed in area, and does not undergo suppuration. Like the chronic form, it is symmetrical, but has a greater tendency to invade the meatus.

No specific bacteria have been discovered, and the histological changes show a striking preponderance of mononucleated leucocytes, the endothelial elements being much fewer. Should resolution occur in a few weeks scarring is rare, but a decided thickening results if the process is more prolonged.

It may be remarked that lupus erythematosus responds much less readily to tuberculin injection than does lupus vulgaris; according to Pick[1] only 50 per cent of cases afforded a positive reaction.

Like lupus vulgaris it is probably due in some instances to tuberculo-toxins, but may also be caused by toxins produced by disturbance of metabolism, since it has been observed in cases of kidney and hepatic disease.

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[1] *Arch. für Derm. und Syphilis*, 1901, p. 350.

Treatment.—When desquamative the scales should first be removed with an ointment of salicylic acid (2 per cent) followed by ichthyol ointment (2 per cent).

Should much irritability appear it is soon allayed by calamine lotion. After having anaesthetised the infected area by means of a subcutaneous injection of cocaine and adrenalin the lupus ulcer should first of all be thoroughly scraped with a sharp Volkmann's spoon, and acid nitrate of mercury followed by pure phenol rubbed into the bleeding surfaces.

This method of treatment, which the writers have found to be peculiarly effective, may be repeated if necessary at weekly intervals.

For the destruction of lupus nodules the insertion of a fine galvano-cautery point into each tubercle causes rapid necrosis of tissue, and is followed by cicatrisation.

In obstinate cases Dewar[1] recommends that an injection of 13 minims of an ethereal solution of iodoform with liquid paraffin be given every second day.

The potassium-silver method of treatment suggested by Hebra is also effective. By means of the local application of a 30 per cent solution of caustic potash the epidermis covering the lupus nodule is rapidly destroyed. The raw surface produced is painted with a 25 per cent solution of nitrate of silver and dusted with xeroform or dermatol powder.

Lancashire[2] recommends, after having bored out the nodules with a wooden skewer, packing the cavity so produced with finely-powdered potassium permanganate and the subsequent application of a drop of water.

This method, although effective, is very slow. Lactic acid, solutions of iodine, chloride of zinc, pyrogallic acid and salicylic acid are also extensively used as local applications, the main essential being to limit the action of the drug to the necrotic tissue, as in this way cicatricial contraction and subsequent deformity is minimised.

Complete removal of a portion of the auricle may be necessary where the disease is extensive and confluent, or where necrosis of cartilage has taken place. Deformity so produced is to be remedied by some form of plastic operation, or by the wearing of an artificial ear. Treatment by means of Röntgen rays or Finsen's phototherapy is now largely employed, and with satisfactory results, especially in the nodular and hypertrophic forms of the disease.

The injection of tuberculin under guidance of the opsonic index is valuable in obstinate cases and where large areas of tissue are implicated.

In addition to local treatment, fresh air, good food, milk diet, and tonics, more especially cod-liver oil, are all useful and necessary.

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[1] *B.M.J.*, March 10, 1907.

[2] *Ibid.* October 24, 1898.

16. Syphilitic Affections of the External Ear.—Primary syphilis of the external ear is exceedingly rare. Cases of chancre have been described by Lang,[1] Pellizzarri, Zucher, and Hermet. The lobule and the lower portion of the auricle are the regions most usually implicated.

Secondary syphilitic affections of the auricle and auditory meatus occur frequently as part of a general syphilitic infection appearing in the form of macular, papular, or pustular eruptions, condylomata or superficial ulcers.

Tertiary syphilitic affections of the auricle and auditory meatus—gummata and ulcers—are somewhat uncommon.

In a case seen by the writer both auricles were much deformed as the result of cicatricial contraction following gummatous ulceration, the patient subsequently dying from syphilitic myelitis.

The most frequent manifestation of syphilis affecting the external ear is the presence of condylomata either around the orifice of the auditory meatus or within the meatus itself, associated as a rule with condylomata elsewhere in the body, and with evidences of pharyngeal syphilis. Commencing as minute red or greyish-red excrescences, they gradually attain a size sufficient to cause occlusion of the meatus. Their growth is accompanied by considerable swelling and oedema of the meatal walls, and by the exudation of a thin, acrid, and foetid secretion. In the early stages of their development they give rise to little or no inconvenience, and are hence rarely observed; but as they increase in size considerable pain and difficulty in mastication is complained of. Their presence tends to induce a diffuse otitis externa. Deafness and tinnitus may also be present when the meatus is stenosed, or when a consecutive inflammation of the middle ear is present.

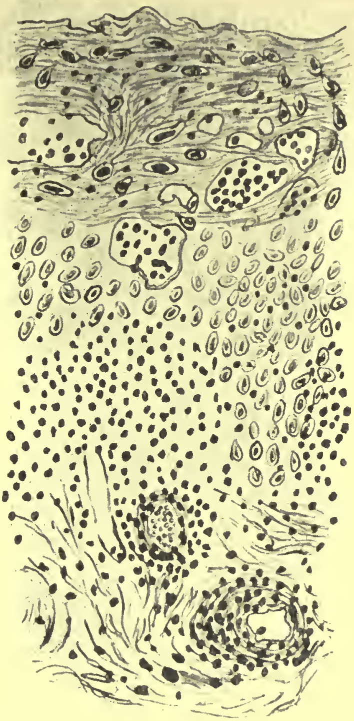

FIG. 71.—Primary syphilis showing perivascular lymphocytosis. Obj. $\frac{1}{8}$ in.

After a varying duration they may resolve entirely, leaving no trace of their former existence, or end in the production of unhealthy ulcers, frequently resistant to treatment. When healing does ultimately take place the skin covering the site of the ulceration is thin, white, and devoid of hair follicles. In exceptional cases cicatricial stenosis of the meatus may result.

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[1] *Pathology and Treatment of Syphilis*, Wiesbaden, 1885.

Ulceration occurs, as a rule, in conjunction with suppuration of the middle ear, and attacks usually the antero-inferior walls of the meatus and the concha. The ulcer is deep, sharply defined, bounded by steep, overhanging edges, and covered by a thin ichorous secretion.

After healing has taken place severe cicatricial contraction, and at times complete stenosis of the meatus, takes place.

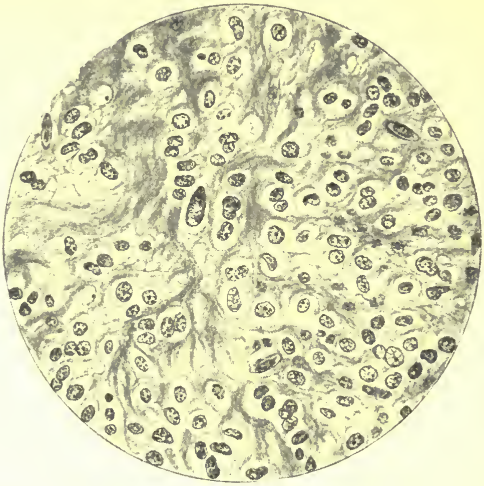

FIG. 72.—Section through the superficial part of a chancre of the meatus. Obj. $\frac{1}{8}$ in.

Pathology.—Figs. 71 and 72 illustrate the histological details of a primary sore of the auricle. It presents no special peculiarities, and conforms to the structure of a chancre which might occur on any other cutaneous surface. The surface epithelium is considerably thickened and infiltrated by lymphocytes. There is also a marked increase of lymphocytes in the lymphatic spaces and of vessels with distinct infiltration of their endothelial lining. Cells, in all respects like plasma cells strongly selective of pyronin, are found in the connective-tissue spaces mingled with wandering polynuclear lymphocytes. The section shows deep infiltration, and was taken from an excised chancre of the auricle of four weeks' duration.

Condylomata present much the same features, except that the surface epithelium is not so thick and is more densely infiltrated by lymphocytes and leucocytes (Fig. 73), while the deeper parts are soft and seroedematous.

Diagnosis.—Unless carefully examined, condylomata may be mistaken for ordinary granulation tissue. The existence of other evidences of syphilis, genital, cutaneous, pharyngeal, or glandular, is of the greatest value in leading to an accurate diagnosis.

Prognosis.—The prognosis of condylomata is favourable, as is also that of the tertiary manifestations, provided that active local and constitutional treatment is at once instituted.

Treatment.—General antisyphilitic treatment should be adopted as soon as a diagnosis has been made.

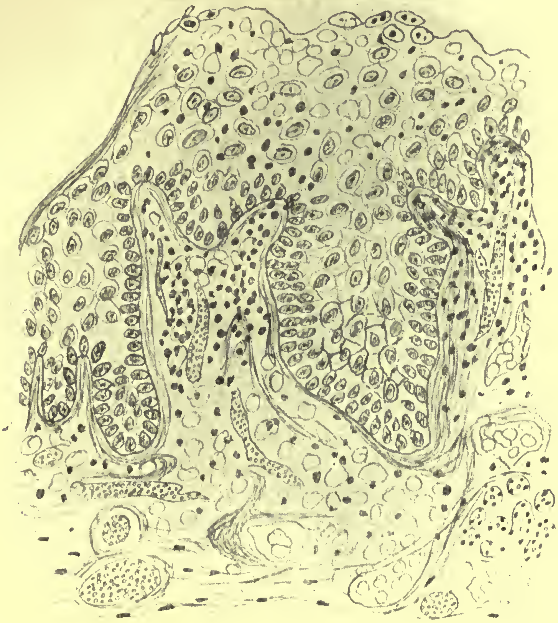

FIG. 73.—Secondary syphilis. Section of "mucous patch" from meatus. Obj. $\frac{1}{8}$ in.

Condylomata should be destroyed by the local application of concentrated chromic acid or pure phenol, or by clipping them away with a pair of scissors. Dusting their surfaces with calomel or iodoform powder is at times useful. The auditory meatus should be frequently syringed with 1-1000 solution of biniodide of mercury and lightly packed with iodoform gauze.

Ulcerated areas should be painted with pure tincture of iodine or nitrate of silver (gr. xx to 1 oz.) and covered with an antiseptic dressing.

The tertiary manifestations—gummata and deep ulcers—should be treated by the internal administration of mercury and iodide of potassium or iodipin, with or without mercurial inunction. When iodide of potassium administered by the mouth is not tolerated it may

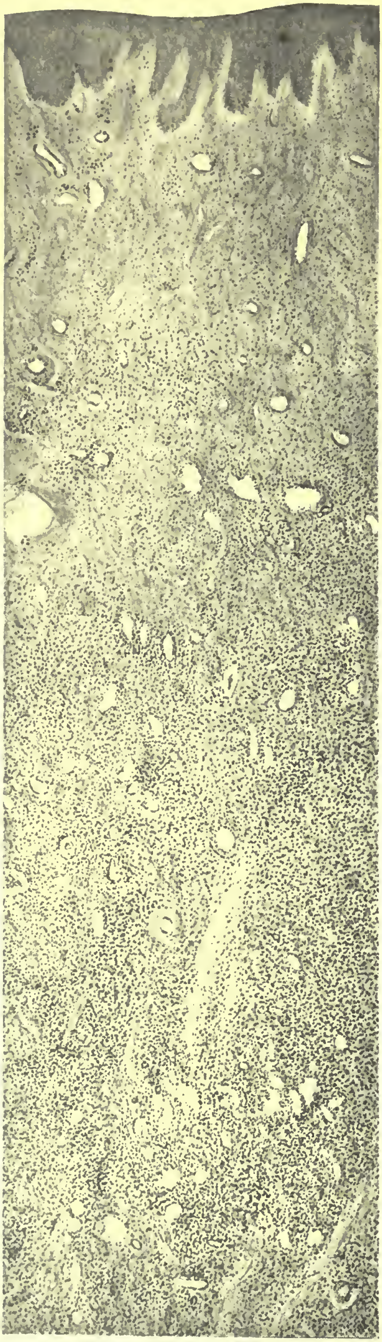

Fig. 74.—Tertiary syphilis. "Gummatous" deposit in auricle and meatus. Obj. 1 in.

be injected into or around the gums, twenty to thirty drops of a 3 per cent solution, to which a little guaiacyl calcium has been added to relieve pain, being employed.

Intramuscular injections of hydrol, or benzoate of mercury, are also of service.[1]

To promote efficient tissue metabolism, the administration of sulphur waters and the employment of hot-air baths is useful.

Where there is a tendency to cicatricial stenosis of the meatus it may be necessary to insert a thin gold tube or plug to preserve its patency.

In exceptionally stubborn cases a course of the waters at Aix-la-Chapelle is advisable.

17. **Haematoma Auris.**—Effusion of blood between the perichondrium and the cartilage of the external ear, or within the cartilage itself, occurs either spontaneously or as the result of some injury—traumatic haematoma.

(*a*) **Spontaneous Haematoma Auris.**—Spontaneous haematoma auris is a comparatively rare affection, and is due to certain degenerative changes which take place in the cartilaginous framework of the auricle, followed by deficient support to its blood-vessels and by their subsequent rupture. Such degenerative and trophoneurotic changes are met with in old age, in tuberculous and syphilitic subjects, and amongst those mentally afflicted. Repeated injury to the auricle, however slight, so common on account of its exposed position, may induce such softening and degeneration. The affection has been so frequently met with in asylums that various mental diseases, such as general paralysis and epileptiform mania, are regarded as definite predisposing causes. Colour has also been given to this theory as the result of the experiments of Brown Sequard, who found that division of the restiform bodies in animals induced haemorrhage into the cartilage of the external ear and its perichondrium.

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[1] Up to the time of writing the effects of "606" have not afforded reliable evidence of permanent curative value.

As, however, spontaneous haematomata are more frequently met with upon the left ear, and very rarely bilaterally, it is probable that even in asylums injury may be an important causative factor.

Spontaneous haematomata occur upon the outer surface of the auricle, and exhibit great variation in size, colour, and consistence. They seldom attain the size of traumatic haematomata. Usually their first appearance is symptomless and their development rapid. When, however, their contents suppurate, pain and other inflammatory symptoms are complained of.

Owing to the fact that various tissue changes have preceded and attended their formation, subsequent cicatricial contraction and deformity is usual.

(*b*) **Traumatic Haematoma.**—As the result of injury to the external ear, rupture of blood-vessels may take place with consequent effusion of blood between the cartilage and its perichondrium. A swelling of varying shape and size, situated usually upon the anterior surface of the auricle, results. This swelling is at first soft and fluctuating, but later on, when coagulation of blood has taken place, feels semi-solid and irregular. The normal elevations and depressions of the auricle become obliterated, a smooth oval-shaped swelling ultimately occupying the upper two-thirds or thereby of its anterior surface and occasionally encroaching upon its posterior surface. In exceptional cases occlusion of the meatus may be produced.

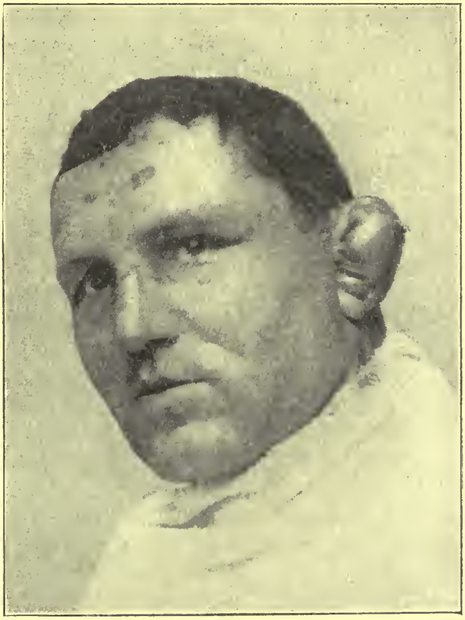

Fig. 75.—Haematoma auris (traumatic).

Traumatic othaematomata are almost invariably found upon the left side. They are very rarely bilateral. They may be produced by such acts of violence as a blow upon the ear, a fall, or a contusion whilst boxing or wrestling (Fig. 75).

Pathology.—Traumatic haematoma of the auricle represents what in most other regions would be a bruise, *i.e.* an extravasation of blood following damage to many of the small vessels scattered among the contused tissues. In the auricle, however, one or more large vessels are torn, from which the blood dissects out a cavity more or less complete. This is due (see Fig. 5) in part to the special histological peculiarities of the auricle, and in part to the fact that the ear is in apposition with a smooth, hard and unyielding surface, which affords a fixed resistance to a sharp blow on the ear as from a fist or from falling against furniture.

In this form of othaematoma the effusion may occur on one or both aspects of the cartilage. It is chiefly confined to the well-marked layer of reticular tissue which separates the skin from the cartilage. As will be seen in the drawing, this is really part of the perichondrium. The cartilage itself may be torn, or the effusion may pass through natural clefts formed apparently by cyst-like distension of the cartilage cells. When effusion is rapid, the blood may soon clot or remain fluid for several days enclosed in one space or in an anfractuous cavity. If uncomplicated by inflammation or mechanical interference, the clot will shrink and the serum become absorbed, but the fibrin either remains as a tolerated foreign body or is organised. At all events, it produces a certain amount of deformity, since it never quite disappears. Following the injury, there will always be some local leucocytic and endothelial activity; but this soon ceases unless infection occurs, when suppuration ensues, with local or diffuse cellulitis and great destruction of tissue.

When the effusion is slow, only the fluid portion of the blood escapes and distends the spaces in the reticular tissue, constituting a species of oedema. Blood pigment may, however, be present, and impart a dark appearance to the swelling. This particular form may terminate in reabsorption without any permanent change in the contour of the auricle.

While sclerotic and other degenerative changes in the vessels may predispose to rupture, this cannot apply in most cases, since othaematoma is not confined to old age, but occurs quite as frequently in young people.

Symptoms.—A traumatic haematoma presents at first as a smooth, bluish-red, oval or rounded swelling occupying the upper and anterior surface of the auricle. To transmitted light it is quite opaque, except perhaps, at its extreme periphery, when it may be semi-translucent. In the event of any inflammatory reaction taking place, it becomes of a deep blue or almost purple colour, is painful to touch, and causes a feeling of heat and oppression upon the affected side.

If suppuration take place, infection of the cartilage and at times of the cutis ensues, with perforation and ultimately cicatricial contraction and deformity. In severe cases the whole external ear becomes shrivelled up. Occasionally fibrous or cartilaginous growths result. Cases of gangrene of the auricle and fatal pyaemia have also been observed.

In the event of the auditory meatus becoming occluded in consequence of swelling and oedema of its walls, deafness and tinnitus supervene. In exceptional instances the membrana tympani has been found ruptured as the result of the original violence.

Differential Diagnosis.—The sudden and rapid appearance of the swelling obliterating the contour of the auricle, combined with the history of an injury and the presence of fluctuation, serves to distinguish haematoma from a new growth, from perichondritis, or from a cyst.

Treatment.—In the early stages, shortly after effusion has occurred and before coagulation of blood has taken place, evenly distributed pressure may serve to bring about absorption. This is best effected by enclosing the auricle between pads of Gamgee tissue and binding it firmly to the side of the head with an elastic bandage. Painting the surface of the swelling with tincture of iodine has been recommended, but is of little service. The application of acetate of lead is better.

The use of cold in the form of an ice-bag, Leiter's coil, or pieces of lint wrung out of ice-cold water and locally applied, is at times useful.

Aspiration of the fluid contents of the swelling is also serviceable if undertaken before definite coagulation has taken place. On account of the occasional re-filling of the cavity with blood, aspiration may have to be repeated several times.

If inflammatory symptoms are absent massage may be found efficacious.

When, on the other hand, coagulation has taken place, free incision and evacuation of the contents of the haematoma, both fluid and solid, may be called for.

Should inflammatory symptoms manifest themselves the application of Goulard's or Burow's lotion or of boracic fomentations is useful. The application also of from four to six leeches around the inflamed area is at times beneficial.

When suppuration has taken place no time should be lost in opening and draining the cavity. The greatest care should be taken to secure and to maintain free drainage, otherwise septic inflammation of the cartilage may follow.

Despite the greatest care in treatment, shrivelling up of the auricle with permanent deformity takes place in a certain number of cases.

18. **Perichondritis of the Auricle.**—This troublesome and frequently protracted affection of the external ear comes on at times without any apparent cause, at other times as the result of infection from some wound of or injury to the auricle, or as a complication of furuncular inflammation of the auditory meatus. It is also said to be

occasionally due to syphilis and gout. It has been frequently noted in cases of radical mastoid operations, where flaps have been cut from the cartilage of the external ear, especially when the incision has been prolonged well into the concha, and subsequent infection of its cut edges has taken place.

The organism often responsible for the production of post-operative perichondritis is the bacillus pyocyaneus. To Pes and Gradenigo is due the credit of having demonstrated the causal relation between this organism and perichondrial abscesses. In 4 cases examined by Leutert a pure cultivation of the organism was found. In 2 cases seen by the authors the pus possessed a brilliant green colour, and contained the bacillus pyocyaneus in pure culture.

Perichondritis may affect a part or the whole of the external ear—the lobule excepted—and, as a rule, commences upon its outer surface. It may, however, start in the auditory meatus and spread slowly over the whole of the external ear. Its course is usually protracted, lasting as it does from a few weeks to a few months. It is very rarely bilateral and symmetrical.

Pathology.—Perichondritis of the auricle occurs both as an acute and as a chronic disease.

(*a*) **Acute Perichondritis.**—Acute perichondritis is marked by rapid leucocytic infiltration of the loose reticular tissue which separates the perichondrium from the skin. This soon attacks the perichondrium itself, and owing to the presence of clefts in the cartilage, may involve both aspects of the auricle. The rapidly forming pus may be limited, or may involve a considerable area, leaving the cartilage quite bare and causing permanent deformity if not soon evacuated.

Spontaneous cases seem to arise by inflammation of the sebaceous glands and hair follicles, the result of streptococcal infection. In traumatic cases a Gram – diplococcus is often found alone, while the post-operative form shows the same diplococcus together with the bacillus pyocyaneus.

The intense pain is explained by the course of the nerves, which not only run in the perichondrium but also pierce the cartilage (Fig. 5).

(*b*) **Chronic Perichondritis.**—Chronic perichondritis differs from the acute form chiefly in intensity. Lymphocytic and endothelial activity is much more marked than leucocytic, consequently there is a greater tendency to either granulomatous formation or to sclerosis and deformity, especially in gouty and tuberculous subjects. It sometimes happens that there is marked local serous distension of the cellular tissue, which leaves a permanent thickening of the perichondrium. Such occurred in a patient seen by the writer, who had permanent and extensive deformity of one auricle due to thickening of the cartilage. As the patient, a female aged forty-five, had a suspicious history of tubercle, Koch's old tuberculin was injected, but with negative results. Subsequent observation proved the lesion to be of a gouty nature.

Symptoms.—In its early stages the tissues covering the outer surface of the auricle become inflamed, swollen, and very tender. They feel hot to the touch, and the surface temperature is found to be considerably elevated. In consequence of swelling and oedema the perichondrium becomes greatly thickened at the expense of the normal contour of the auricle, the whole external ear appearing as a soft, translucent, and pendulous bag. Although the most marked changes are to be found upon its outer surface, its mesial surface is also frequently affected, with the result that the whole auricle stands out from the side of the head and droops downwards and forwards. Sometimes prior to suppuration taking place, the swelling is quite translucent, thus distinguishing it from an othaematoma. When, however, suppuration does take place, all existing inflammatory symptoms increase in intensity, and objective appearances become more pronounced. The inflammatory process may come to an abrupt termination at one portion of the auricle, only, however, to start at another and, perhaps, distant part. The disease, as a rule, runs a protracted course, if unrelieved, and may end in complete resolution without deformity, in shrivelling up and permanent deformity, calcification, and at times true ossification of the infected areas. The acute form is always associated with intense pain.

Treatment.—The main indications are to relieve tension, and to afford an exit for the products of inflammation, purulent or non-purulent. No time should be lost in freely incising and draining softened and oedematous areas. The more quickly tension is relieved and free exit afforded for the serous or purulent contents of the swelling, the better are the chances of rapid resolution, but in some cases the changes soon assume the character of solid oedema when only scanty serous fluid slowly oozes away. It is therefore often advisable to make several small incisions or punctures, and to introduce strands of horsehair so as to maintain drainage. Urban Pritchard recommends puncture and injection of equal parts of tincture of iodine and rectified spirits.

Repeated puncture and aspiration has also met with some success.

In post-operative cases, swabbing the mastoid cavity with a 2 per cent solution of nitrate of silver, and subsequent dressing of the auricle with gauze soaked in alcohol, has proved efficacious.

When the contents of the cavity are purulent, free incision and packing with strands of gauze is called for. In severe cases, where necrosis of cartilage has taken place, it is necessary to scrape all necrotic areas, and at times to perforate the cartilage completely, so as to ensure effective drainage. In two cases of great severity seen by the author, several perforations were made through the cartilage, and strands of gauze inserted with excellent results. In dressing the part it is advisable to exert a certain amount of graduated pressure by embedding the inflamed auricle between pads of Gamgee tissue, and applying an elastic bandage round the head.

CHAPTER IX

FOREIGN BODIES IN THE EAR CLEFT

Foreign bodies in the ear may be either animate or inanimate. Inanimate foreign bodies, such as peas, beans, beads, grains of corn, pencils, shot, buttons, fruit stones, matches, pieces of cotton wool, paper, etc., may be introduced into the auditory meatus by the individual himself or by some other person. Cases are recorded where foreign bodies, *e.g.* pieces of wood, bone, etc., have been repeatedly introduced into the meatus for the purpose of exciting the sympathy of those charitably inclined. They are found much more frequently in the ears of children than in those of adults, where their introduction is usually a purely accidental circumstance.

Foreign bodies may remain in the ear for very long periods without causing symptoms of irritation. Their discovery is often purely accidental, and is frequently associated with the occurrence of sudden deafness due to a collection of cerumen around the foreign body and its subsequent impaction.

Cases are on record where a foreign body has remained as long as fifty years in the ear without producing the slightest inconvenience. In one case which came under the author's notice a boot button had been in the ear for thirty-seven years, and was known to have been there; in another, a piece of slate pencil had been in the auditory passage to the patient's knowledge for thirty years.

Practical experience proves conclusively that unskilled attempts to remove foreign bodies from the ear do infinitely more harm than the actual presence of the foreign body itself. As the result of unskilful manipulations the foreign body is frequently pushed beyond the junction of the cartilaginous with the bony portion of the meatus, its narrowest part, into and beyond the isthmus, and at times through the membrana tympani into the tympanum. In a case seen by the author the membrana tympani, the malleus, and the incus were forcibly torn out under the impression that a foreign body was being removed. The resulting injury to the tympanum was followed by profuse suppuration and partial (permanent) facial paralysis.

In addition to possible injury to the contents of the tympanum, crude attempts at removal, especially when made without adequate illumination, are prone to set up an otitis externa with subsequent stenosis of the meatus, thereby rendering extraction a matter of extreme difficulty, if not impossibility, until after the employment of some sedative treatment.

Where the foreign body has been pushed through the membrana tympani, septic otitis media almost invariably ensues, at times with permanent damage to the middle ear, or the walls of the labyrinth become infected with subsequent extension to its contents, and even occasionally to the base of the brain.

Fatal cases of meningitis following unsuccessful attempts to remove foreign bodies have been recorded by Schwartze.[1] In this case, where the membrana tympani had been torn and the cochlea, vestibule, and semicircular canals contained pus, the auditory nerve was in a state of purulent degeneration.

Diagnosis.—The diagnosis of a foreign body in the ear is, as a rule, a simple matter, inspection revealing its presence, situation, size, and contour. Occasionally, when surrounded by cerumen or dried blood-clot a correct diagnosis may be difficult. It frequently happens that a foreign body is stated to be in the ear when inspection shows this not to be so. In every case, therefore, when a statement has been made that a foreign body exists in the ear, its presence should be verified before any attempt at extraction is made.

Symptoms.—The presence of a foreign body in the ear gives rise, as a rule, to but few symptoms. Certain reflex phenomena, such as spasmodic coughing, "toothache," retching, and facial neuralgia are at times induced as the result of irritation of the terminal filaments of Arnold's nerve, or the auriculo-temporal branches of the fifth nerve. Attacks of *petit mal*, hemianaesthesia, and persistent vomiting have been recorded as due to the presence of a foreign body and as cured by its removal.

Deafness may suddenly supervene from impaction of the foreign body, from accumulation of cerumen around it, or from acute inflammation and oedema of the meatal walls, whilst tinnitus is invariably complained of should it come to lie in contact with the membrana tympani.

Most of the symptoms produced by foreign bodies in the ear are, however, due not so much to the presence of the foreign body itself as to the disastrous results which follow inexperienced and unskilful efforts of extraction.

The resulting inflammatory lesions of the external and middle ear, and even of the internal ear, which may follow, are at times extremely serious, and may end in partial or total loss of hearing upon the affected side and in exceptional cases fatally.

Treatment.—The removal of a foreign body from the auditory meatus is, as a rule, a matter of comparative simplicity provided that previous manipulations have not forced it beyond the junction of its cartilaginous and bony portions, and provided also that the walls of the meatus are not swollen and oedematous as the result of mechanical injury.

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[1] *Arch. f. Ohrenhlk.* Bd. 70, Hefte 1 and 2, p. 110.

In every case a careful examination should be made so as, in the first place, to verify the presence of the foreign body; and, in the second place, to reveal its nature, size, and situation. Provided that the nature of the foreign body has been ascertained, the safest and, as a rule, the best method of removing it is the employment of the syringe and warm water. A good-sized brass ear-syringe with fine nozzle should be used, and the stream of fluid forcibly injected along that meatal wall with which the foreign body is least in contact. Or a piece of fine rubber-tubing may be attached to the nozzle of the syringe and passed up to, and if possible, beyond it. The increasing *vis a tergo* as the result of the forcible injection of warm water forces the foreign body outwards towards the aperture of the meatus, whence it may be picked out with a pair of forceps. At the same time the auricle should be held upwards and backwards so as to straighten the meatus, and in cases of exceptionally heavy bodies, such as pieces of lead, iron, or shot, the patient may be directed to lie upon his back with his head turned over to the side. After every second or third syringeful of water the meatus should be inspected to ascertain if the foreign body has become dislodged.

Such bodies as peas, beans, grains of Indian corn, etc., readily absorb fluid, and so tend to become swollen and still further impacted. Under such circumstances the preliminary instillation of rectified spirits and cocaine dissolved in glycerine by causing their dehydration and consequent contraction, assists materially in their subsequent extraction.

In uncomplicated cases the syringe, if skilfully used, seldom fails. Cases occur, however, where, owing to impaction of the foreign body forcible syringing is ineffective. Under such circumstances Loewenberg suggested the "agglutinative" method. An ordinary camel's-hair paint-brush is taken, dipped into a strong solution of glue or seccotine, and passed down into contact with the previously dried foreign body. Sufficient time is allowed for the glue to set firmly, after which traction is made and forcible extraction effected. Solutions of formol gelatine, thick collodion, or celloidin act almost better than glue, setting much more rapidly, and adhering more intimately to the foreign body. An ingenious suggestion made by Lucae for the removal of glass beads which present end outwards, consists in passing a laminaria tent through the central opening, allowing it to gradually expand with the natural heat of the meatus, and then applying traction.

Should syringing be ineffective or inapplicable owing to the presence of a perforation of the membrana tympani, resort may be had to some form of hook (Fig. 76), spoon, curette, or specially constructed forceps.

In removing a round, smooth, foreign body from the meatus it should be borne in mind that its posterior wall is level or slightly concave, not convex like its other boundaries. By keeping a small curette pressed towards the posterior wall at an acute angle and well beneath the foreign body, removal is easily effected by slight leverage and traction outwards.

To accomplish this the patient should lie down upon the opposite side, with the surgeon standing behind. The curette is then passed between the foreign body and the anterior meatal wall, and, as it cannot slip backwards, it must come forwards, the auricle being meanwhile well retracted.

When dealing with children it is, as a rule, advisable to administer a general anaesthetic, as any sudden and unexpected movement of the head may result in injury to the walls of the meatus, if not to the membrane itself.

In cases of impacted peas, beans, or other semi-solid bodies it may be possible to drive a hook into their substance, and then to extract by forcible traction. Boring a hole through such foreign bodies as impacted cherry-stones, plum-stones, etc., by means of a minute awl or fine galvano-cautery point has also been suggested as a preliminary before inserting some form of hook for traction purposes.

Guye's fenestrated forceps and Politzer's gouge forceps are also useful instruments in special cases and under certain circumstances.

The particular instrument used and the exact method of its application will depend largely upon the ingenuity and resourcefulness of the surgeon.

Where there is inflammatory swelling and oedema of the meatal walls, and where, as a result, the foreign body is tightly held in position and partially concealed from view, sedative or anti-phlogistic treatment should be employed for a few days, provided that no symptoms of urgency are present before extraction is attempted.

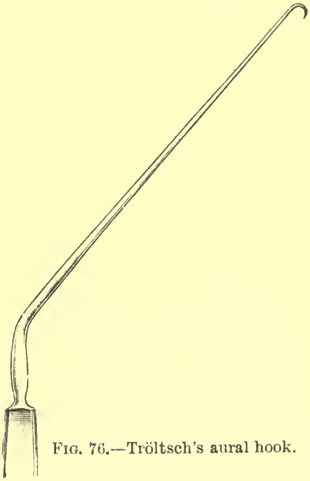

Fig. 76.—Tröltsch's aural hook.

In urgent cases solutions of cocaine and adrenalin, or of liquor aluminis acetici, will be found to quickly relieve the existing stenosis.

In less urgent cases lotions containing cocaine, eucaine β, morphia, or opium with or without the addition of rectified spirits, will be found useful. The application of a Leiter's hot or cold coil around the auricle, or the local abstraction of blood by means of leeches, serves to relieve the swelling of the tissues.

When, on the other hand, urgent symptoms, such as deep-seated pain, retention of pus, choked disc, cerebral hyperaemia, or labyrinthine irritation are present, no time should be lost in detaching the auricle and extracting the foreign body. It occasionally happens that a foreign body is pushed through the membrana tympani, and becomes wedged in the tympanic cavity.

In certain cases of impacted metallic steel foreign bodies, removal has been effected with the electro-magnet.

Failing its removal by means of syringing or intrameatal instrumentation, it is necessary to detach the auricle. For this purpose an incision is made behind and parallel to its attachment through skin and periosteum down to the bone. After bleeding-points have been ligatured the periosteum is raised from the underlying bone until the posterior margin of the bony meatus is fully exposed, a portion of its wall being removed with a mallet and gouge if necessary.

The foreign body is then, as a rule, easily extracted with a strong pair of forceps, or levered out with a Lister's blunt-hook (Fig. 77).

In a case seen by the author, of a doll's glass eye tightly impacted about the commencement of the bony portion of the meatus, a ring of bone from the posterior meatal wall had to be removed before it was possible to perform extraction.

In exceptional cases, where the foreign body is tightly impacted within the tympanic cavity, it may be necessary to remove not only a portion of the bony wall of the meatus, but also a portion or the whole of the external wall of the attic.

Foreign bodies, such as grains of corn, fragments of wood, and pieces of straw, have been known to reach the tympanic cavity by way of the Eustachian tube, and to cause acute septic otitis media with perforation.[1]

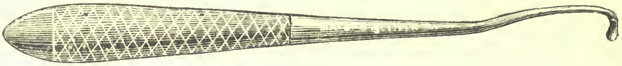

FIG. 77.—Lister's ear hook.

Animate foreign bodies, such as flies, bed-bugs, pediculi, earwigs, cockroaches, etc., occasionally find their way into the external auditory meatus. They may become fixed in the sebaceous and ceruminous secretion present in the meatus, or may pass into its isthmus and lie up against or become attached to the membrana tympani. In the former case they may cause no symptoms; in the latter they are prone to set up an almost intolerable itching, headache, tinnitus, and at times more severe symptoms, culminating in a mild form of delirium. They are most easily removed by the instillation of warm carbolic oil (1 in 40) and subsequent syringing, or by means of a curette or forceps. In a case seen by the author a cockroach had crawled into the external meatus of a male patient, and had become wedged at the junction of its cartilaginous and bony portions. Removal was effected with forceps. A similar case has been recorded by Truckenbrod.

The larvae of insects are occasionally found in the meatus and in cases of old-standing foetid purulent otitis media in the tympanic cavity. Their adherence to the meatal or tympanic walls is at times so intimate that great difficulty is experienced in dislodging them with the syringe. The instillation of oil containing turpentine, ether, or chloroform, invariably, however, causes their displacement. Any inflammatory reaction which their presence may have given rise to is best combated by the instillation of sedative drops containing acetate of lead and carbolic acid.

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[1] Urbantschitsch, *Berlin. klin. Woch.*, 1878.

Foreign Bodies in the Middle-ear Cleft.—A foreign body occasionally reaches the cavity of the middle ear either through the meatus, or by way of the pharyngeal orifice of the Eustachian tube. In the former case the accident is, as a rule, due to the faulty or clumsy methods employed to extract it after it has become impacted in the meatus and been accidentally pushed through the membrana tympani, in the latter to its having entered the tube during the process of deglutition, or as the result of instrumentation. When a foreign body has passed into the tympanum the greatest care is required during the process of extraction to avoid injury to the delicate structures of the middle ear, and should it be at all tightly impacted, it is advisable to detach the auricle, and, if necessary, to remove a portion of the osseous meatus in order to secure the necessary amount of room for freedom of manipulation.

Cases have been recorded where a grain of corn, blade of grass,[1] or a seed has entered the pharyngeal orifice of the Eustachian tube, and has travelled upwards into the tympanum through the membrana tympani, and so into the auditory meatus. In other instances, a foreign body has occasionally been seen by means of posterior rhinoscopy lying in the pharyngeal orifice of the tube.

Occasionally the tip of a catheter or a portion of a bougie introduced into the tube has broken off, and has been seen to project into the naso-pharynx. Under such circumstances it may be removed by one or other form of post-nasal forceps. When tightly impacted it may be necessary, where a perforation of the membrane does not already exist, to perform an exploratory tympanotomy, and to forcibly syringe or inflate per meatum, so as to drive it into the naso-pharynx.

List of 82 *Consecutive Foreign Bodies removed from the Ear.*

	Number.
Beads	22
Artificial drums (rubber)	7
Rolls of paper	4
Locust beans	2
Orange pips	5
Small pebbles	8
Cherry stones	3
Small shells	3
Jequirity seed	1
Collar studs	4
Leaden slug (air-gun)	1

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[1] *Piffl. Archiv f. Ohrenheilk.* Bd. 72, i. and ii. p. 77.

	Number.
Ear-ring	1
Pencil knob (bone)	3
Pencil knob (metal)	1
Plaster toys	2
Artificial gem	1
Boot button	4
Wooden matches	3
Doll's eye (glass)	1
Slate pencil	3
Earwig (dead)	1
Flies (dead)	2
Cockroach (dead)	1
Total	82

Of these various foreign bodies, 56 per cent were in the right ear and 44 per cent in the left ear.

CHAPTER X

DISEASES OF THE EXTERNAL AUDITORY MEATUS

1. Hypersecretion and the Formation of Ceruminous Plugs.—Sebaceous glands exist in large numbers in the cartilaginous portions of the external auditory meatus, ceruminous glands occurring chiefly about the commencement of its bony portion. Under certain circumstances these glands may produce an excessive quantity of secretion, in which case blocking of the meatus and mechanical deafness results. On the other hand, the amount of cerumen normally secreted may be partially or entirely arrested, in which case a dry and irritable condition of the auditory meatus is complained of. Mixed with the cerumen there is a quantity of sebaceous material, epithelium, hair, and atmospheric impurities, the whole forming a plug of varying consistence, colour, and appearance.

In young children the secretion from the ceruminous glands is of a light yellow colour, very scanty, and almost fluid; in adults it forms a thick, greasy, and tenacious exudation of a reddish-brown colour, and is much more copious; whilst amongst elderly people it is found to be hard, brittle, and almost black.

Many ceruminous plugs present a peculiarly mottled appearance from the admixture of flakes of desquamated epidermis. In general, it may be said that the greater the amount of epithelium present the denser the plug, whilst the more fluid the exudation the less the risk of its accumulation in the external meatus.

When removed, a large dense plug may present the appearance of a complete cast of the auditory meatus, its tympanic end showing an elevation and slight depression corresponding respectively with the umbo and short process of the malleus. Such plugs are often foetid. Under ordinary circumstances cerumen, which is secreted, desiccates, comes to the aperture of the auditory meatus, and is removed partly by manipulation, and partly as the result of the movements of the jaw in mastication.

Etiology.—The main causes predisposing to the undue accumulation of cerumen are as follows:—

1. Excessive activity of both ceruminous and sebaceous glands as the result of hyperaemia of the cuticular lining of the auditory meatus.

2. Stenosis and exaggerated curvature of the meatus, either congenital or acquired, *e.g.* from the presence of hyperostoses, exostoses, post-operative stricture, collapse of the cartilaginous walls in old age, etc.

3. The entrance of water into the ear during bathing, diving, washing.

4. The injudicious use of a towel in drying the ear, mechanical irritation, use of aurilaves, etc.

5. Foreign bodies in the ear around which cerumen collects.

6. Circumscribed or diffuse otitis externa.

7. Eczema of the meatus.

8. As a post-suppurative sequela.

9. As an associated symptom in tubal or middle ear catarrh, or as the result of an inflammatory lesion of the labyrinth.

10. It is a frequent sequel to any one of the acute specific fevers, especially scarlatina and measles, and occurs also in gouty subjects. Both ceruminous and sebaceous secretion are increased by physical exercise, also during hot weather and when taking Turkish baths. Occupations entailing great muscular effort in a hot atmosphere strongly predispose, especially in those liable to seborrhoea.

11. In old patients hair often accumulates in large masses, more or less mixed with sebaceous material and squames, forming casts or balls.

Symptoms.—As a rule both ears are affected, one, however, being often much more occluded than the other. As the ceruminous secretion collects in the ear it gives rise to a sensation of fulness and heaviness upon the same side of the head. Deafness, to any appreciable extent, does not develop until the meatus has become completely occluded, or the tympanic membrane compressed. As a rule it is quite sudden, the meatus becoming finally blocked as the result of the entrance of water whilst washing or bathing causing a sudden expansion of the plug, or from impaction due to violent jolting, such as boxing the ear or sudden movements of the head. The resulting deafness, although severe, is never quite complete, unless there exist at the same time some severe lesion of the middle or internal ear. In addition to deafness the patient suffers from *autophony* or hearing his own voice reverberating in his deaf ear.

In certain cases with perforated membrane, the presence of a plug of cerumen may actually serve to improve the hearing, the plug playing the part of an artificial aid.

Subjective sensations of sound—tinnitus aurium—are, as a rule, complained of. These sounds, at times quite continuous, may be high or low pitched, or of a whistling, singing, or musical character, occasionally pulsating and synchronous with the heart's beat, or like the rush of steam issuing from a narrow pipe. In certain cases they are so persistent and annoying as to produce mental depression and even hallucinations of hearing, whilst Politzer mentions the occasional existence of eclampsia, blepharospasm, and facial paralysis as the direct result of impacted cerumen.

In such cases of mechanical impaction, the existing tinnitus is due either to pressure upon the membrana tympani and stapedio-vestibular articulation, or to a reflex auditory stimulus from irritation of the terminal filaments of the fifth or tenth cranial nerves, from both of which fibres go to supply the cutaneous lining of the external auditory meatus and tympanic membrane.

Pain is seldom complained of except in those cases where there is a coexisting ulceration of the membrana tympani or walls of the auditory meatus, when "toothache" is often referred to.

Intermittent attacks of neuralgia are, however, not infrequent.

When severe pressure is exerted upon the membrana tympani and ossicular chain from the presence of a large and dense plug, vertigo may be complained of.

Cases of *petit mal* have been reported as caused by impacted cerumen, and as cured by its removal. Obstinate fits of severe coughing are at times due to the presence of cerumen, the reflex passing along Arnold's nerve, which supplies the lining of the inner portion of the meatus and the lower half of the tympanic membrane, the cartilaginous meatus and upper segment of the membrane being supplied by the fifth nerve.

Diagnosis.—A diagnosis of impacted cerumen is, as a rule, easily made, either by the unaided eye, or by means of a mirror and speculum. The presence of a light-yellow, brownish-red, or black mass filling up the meatus is usually unmistakable. With a probe the sensation imparted is, as a rule, that of a soft, doughy mass, although at times the plug may be hard and brittle. A very thin layer or diaphragm of cerumen lying across the meatus and close to the attachment of the membrana tympani may at times give rise to some confusion, as also may dried blood, impacted cotton wool, or a foreign body around which cerumen has collected, inspissated pus, or cholesteatomatous material. All doubt is easily cleared up by inspection and examination with a probe.

Prognosis.—Provided that the patient has previously possessed good hearing power, and that the onset of deafness has been sudden, and has followed some such act as washing, bathing, etc., it may fairly be assumed that it is of idiopathic origin, and will be remedied by removal of the plug. No definite prognosis should ever be given until the plug has been removed and the membrane carefully examined.

Ceruminous plugs frequently coexist with lesions of the middle and internal ear, and are then merely incidental phenomena. Under such circumstances their removal may produce hardly any improvement in the patient's hearing power, whilst exceptionally, as previously mentioned, an actual deterioration of audition may result.

In post-suppurative otitis media accumulation of cerumen is comparatively common, and is at times an accompaniment of a gradually increasing power of hearing. In other cases, however, *e.g.* adhesive catarrh of the middle ear and certain labyrinthine lesions, an increased activity of the glands is accompanied by no improvement in audition.

The employment of blisters and counter-irritants around the ear favours the activity of the ceruminous glands.

Treatment.—If the impacted plug be soft and greasy, which, as a rule, may be ascertained by inspection, and always by palpation with a probe, it should be removed by means of syringing, the warm fluid being directed along the posterior meatal wall, and directed to the occiput, the auricle being meanwhile drawn upwards and backwards in the adult, downwards and forwards in the child.

If, on the other hand, the plug is dry, hard, and brittle, it should be softened by instillation of a 1 per cent solution of caustic potash in glycerine, and subsequently removed by syringing. Such drops cause softening and contraction of the plug, whilst water causes its expansion.

Occasionally it may be desirable to attempt to move the position of the plug with a curette or a pair of forceps, or to make a channel past it with a probe, so as to permit the ingoing current of fluid to get behind it and expel it by a gradually increasing *vis a tergo.*

Prolonged and forcible syringing of the ear should always be avoided, tending as it does to the production of inflammation of the auditory meatus, or even to auditory concussion.

When the plug is very hard and epidermal a preliminary softening with a 1 per cent solution of salicylic acid in borax glycerine is strongly recommended.

In many cases, however, the employment of solvents as instillations is necessary, the most effective being warm solutions of bicarbonate of soda (gr. xx. to ℥i.), liquor potassii (♏v. to ℥i.), peroxide of hydrogen (ʒii. to ℥i.), or ether.

After one application of any of these solvent drops the plug is, as a rule, readily removed by means of the syringe; but the primary use of watery solutions when the plug is impacted is not desirable.

After its removal the ear should be carefully dried, and lightly packed with sterilised gauze, which should be worn for at least twelve hours, partly to protect the ear from the risk of cold, and partly from the effects of loud sounds.

By attaching a Behag's rubber tube to the end of the syringe the removal of the plug may be more easily accomplished, the tube being passed by the side of the plug, and, if possible, beyond it.

Ceruminous accumulations are prone to recur, the intervals between the re-accumulations varying from a few months to a year or two.

Beyond advising the patient to keep the ear as dry as possible and to avoid irritating it, there is little to be done to prevent recurrence.

The careful use of Politzer's inflation is often necessary when deafness persists after removal of the plug.

2. **Keratosis Obturans.**—As the result of a chronic desquamative dermatitis the auditory meatus becomes blocked at times with epithelium which forms plugs of exceptional hardness. Mixed with the epithelium is a varying amount of cerumen imparting to the plug a peculiar mottled appearance. This condition was first described by Wreden in 1874, and,

although not common, is important from the difficulties encountered in successfully dealing with it.

R. Lake considers that, in the first instance, an ordinary ceruminous plug forms and that, as a result of its presence, a dry scaly eczema is produced around it; whereas Burnett believes that the proliferation of epithelium and subsequent formation of a plug is originally caused by some form of trauma.

In those cases where the plug is in contact with the membrana tympani, or of such a size as to occlude the meatus, deafness is present combined with a varying degree of tinnitus.

Treatment.—To remove such epithelial plugs is in many cases no easy task, on account of their intimate adhesion to the meatal walls. In children and young adults it is advisable to administer a general anaesthetic. When possible the plug should be gently separated with a fine probe from the walls of the meatus and the syringe employed to remove it. Occasionally it may be necessary to use an ear-scoop or fine curette to effect removal. As recurrence is almost sure to take place, the patient should present himself at intervals for examination. Periodic instillations of 1 per cent solution of salicylic acid in alcohol is to be recommended.

3. **Deficient Secretion of Cerumen.**—It is by no means unusual to find a deficient secretion of cerumen amongst those individuals whose skins have a marked tendency to dryness, amongst old people, and in cases of circumscribed or diffuse otitis externa and eczema of the meatus which have run their course.

In certain cases of dry middle ear catarrh with atrophy, in otosclerosis, and amongst those who habitually syringe their ears, the external meatus frequently appears dry, white, and glistening, and of somewhat larger calibre than usual.

Owing to some trophic disturbance the glandular elements of the cutaneous lining of the meatus atrophy, and in certain cases disappear entirely.

Any existing deafness is in no way, however, due directly to deficient ceruminous secretion, but indirectly to some concomitant lesion of the middle or internal ears, or accumulation of scales and dust which does not happen when the secretion is normal.

In cases of protracted suppuration from the cavity of the tympanum, the secretion of cerumen is much less than should normally be the case, or is even in complete abeyance.

After the suppurative process has, however, become arrested, it tends to increase in amount to such an extent as at times to produce definite obstruction. Apart from its association with the above named aural diseases, deficient secretion is essentially an attendant of old age and malnutrition. It has been observed in glycosuria.

The main symptom complained of is a feeling of dryness and local irritation.

Treatment.—To allay the sense of dryness and of irritation, the skin lining the meatus should be painted with some stimulating lotion, such as tincture of iodine, or pencilled with a dilute mercurial ointment, lanoline, or vaseline and menthol.

Counter-irritation over the mastoid process affords a sense of relief, and also stimulates the ceruminous glands to an increased activity.

Concomitant disease of the middle or internal ears should be treated upon ordinary principles.

It should be borne in mind, however, that even although the existing lesion of the middle or internal ear improves under treatment, it does not follow that there will be any increase of glandular activity ; nor, on the other hand, that an increase in the amount of cerumen is necessarily accompanied by an improvement in hearing.

Should there be any accumulation, epidermal or air borne, it may be removed by the measures already described. The parts may be kept soft and collections prevented by occasionally instilling drops of salicylic acid —1 per cent—dissolved in glycerine of borax.

4. **Otitis Externa Circumscripta** (*Otitis externa follicularis*).—Circumscribed inflammation of the external auditory canal is a comparatively common and an exceedingly painful affection. It may be acute or chronic.

It is due primarily to the entrance of the staphylococcus pyogenes albus or aureus into the sebaceous glands or hair follicles of the integument lining the auditory meatus (Löwenberg, Kirchner, Schimmelbusch). In many cases a Gram – diplococcus has been found in pus taken directly from a furuncle (Wingrave). Consequently it is much more frequently met with in the superficial portions of the meatus on account of the anatomical distribution of these glands. Abrasions of the cutis, especially when situated upon the floor of the meatus or just inside the tragus, are largely responsible for the production of furuncles. Occasionally one furuncle will be found upon the posterior wall of the meatus, and another upon its anterior wall, the one exactly opposite the other. A furuncle may take its origin in the superficial portions of the cutis or more deeply in the perichondrium. In the former case its development may be comparatively painless; in the latter severe symptoms, both general and local, may result. It is frequently very difficult, especially amongst children, to draw the line between furunculosis and cellulitis.

Furuncles are met with in apparently perfectly healthy individuals as well as amongst those whose powers of resistance are diminished as the result of loss of blood, diabetes, or anaemia. Frequently they occur along with furuncles in other parts of the body, and are common in anaemic women, especially about the time of the menopause. They may follow acute specific fevers, and are often an accompaniment of glycosuria.

Certain local conditions influence their incidence, such as abrasions the result of mechanical irritation, eczema of the meatus,[1] chronic suppurative otitis media, and the prolonged employment of alum lotions (v. Tröltsch). The internal administration of bromide and iodide of potassium in large doses and extending over long periods, is also an important aetiological factor in their development (McBride). They are more frequently met with in adults than in young people, and show a remarkable tendency to develop in spring and autumn. Well authenticated plagues of boils have been placed on record.

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[1] Seligmann, *Münch. med. Wochen.*, Oct. 30, 1906.

Pathology.—There are two distinct varieties or degrees, one which primarily attacks and remains confined to the sebaceous glands and hair follicles, the other which involves the deeper structures and constitutes focal perichondritis or periostitis according to the region attacked. Most cases are due to an infection from a staphylococcus, especially the recurring form, but streptococci and diplococci (Gram –) are often found.

Supplementary to these are the air and water borne penicillium glaucum, and the bacillus proteus vulgaris with the bacillus coli communis, probably conveyed by the fingers. Should the inflammation be severe, leucocytic and lymphocytic, infiltration may extend far beyond the gland and become a circumscribed cellulitis, which in children may point in front of or behind the auricle, but in adults such a termination is more likely to be due to gland infection. Either form may be attended with considerable and extensive oedema, so that the exact site may be obscured. In each case an abscess is formed which simply varies in extent and degree.

Symptoms.—The symptoms vary according to the situation of the furuncle, whether in the cartilaginous or in the bony portions of the meatus, and whether originating in the superficial layers of the cutis or in the perichondrium.

The more deeply situated the furuncle the greater the amount of discomfort complained of, due to the close relationship between the cutaneous portions of the meatus and the periosteum. The pain which, at the commencement, is local, rapidly radiates over the affected side of the head, and is aggravated by any manipulation of the ear or movement of the lower jaw. Should occlusion of the meatus result from swelling and oedema of its walls, varying degrees of deafness and tinnitus ensue. A general sense of fulness over the affected side of the head is complained of, and in the early stages of the development of the furuncle, especially when deep seated, slight rises of temperature may be noted at night, also vertigo, "toothache," and salivation.

A concomitant hyperaemia of the middle and internal ears is occasionally present in severe cases.

In cases where the furuncle develops in the superficial layers of the cutis, inspection reveals a sharply-defined, red, and very painful swelling, tender on palpation with a probe, and presenting at times a yellowish tinge around its apex.

Where, on the other hand, its development takes place more deeply, the resulting irritation is considerably greater, the swelling more diffuse, and its colour practically similar to that of the adjoining skin.

On comparing the auricles by posterior inspection it is not unusual to find that the affected one is the more prominent, especially when the osseous region of the meatus is the seat of inflammation.

In exceptional cases the swelling and oedema is so great as to produce a downward and outward displacement of the auricle simulating an attack of mastoid periostitis, or, on the other hand, it may spread forward over the side of the face causing closure of the eyelids. In cases of furunculosis the retro-auricular fossa is obliterated, whereas in cases of mastoiditis it is preserved (Fig. 78).

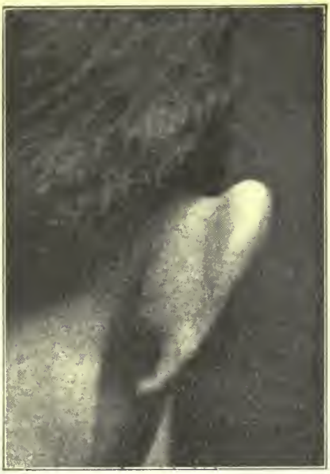

Fig. 78.—Downward and forward displacement of auricle and obliteration of retro-auricular groove in a severe case of aural furunculosis.

Glandular enlargement is not uncommon in severe and in chronic cases.

Treatment. — The first and foremost indication is to relieve the excessive pain complained of. The instillation of anodyne lotions containing cocaine, or the local abstraction of blood by means of a few leeches placed around the ear, as a rule, affords considerable relief.

Gauze wicks, soaked in a 4 per cent solution of carbolised glycerine and packed lightly into the meatus, are of use on account of the antiseptic and analgesic properties of carbolic acid. Repeated douching with warm antiseptic lotions containing carbolic acid, perchloride or biniodide of mercury, or hot compresses of aceto-tartrate of aluminium and lead acetate are also beneficial. In cases due to the bacillus pyocyaneus the insertion of gauze wicks soaked in a 2 per cent solution of nitrate of silver is efficacious.

The most speedy and effective method of relief is incision and evacuation of the contents of the furuncle.

On account of the pain produced it is advisable in children to administer a general anaesthetic such as nitrous oxide or chloride of ethyl; in adults the production of local anaesthesia by the instillation of Gray's solution, or the subcutaneous injection of cocaine (Neumann) is usually sufficient. The incision should be made by means of a tenotomy or specially constructed furuncle knife (Dundas Grant) (Fig. 79) across the most prominent part of the swelling and from within outwards.

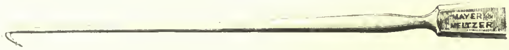

Fig. 79.—Dundas Grant's furuncle knife.

In cases of deeply-seated furuncles it is advisable to cut right down to the underlying bone, so as to secure thorough division of all indurated and inflamed tissue. Even should pus not be present tension is at once relieved. After incision gentle pressure over the indurated area assists materially in getting rid of any retained pus or slough (the core) which is almost invariably present. The fact also that the furuncle is freely laid open renders it possible for medicated solutions to find access to the centre of the disease.

The injection of a few drops of a 5 per cent solution of carbolic acid into the centre of the furuncle has been recommended (Weber-Liel, Bendelak Hewetson), as also has the application of solid nitrate of silver to its surface. The first of these methods is, however, in the experience of the writers, ineffective and very painful unless when preceded by incision.

Politzer recommends the use of a Leiter's warm coil.

After incision and evacuation of the contents of the furuncle the meatus should be steeped in a 5 per cent solution of carbolised glycerine, or equal parts of hydrogen peroxide and rectified spirit, boracic acid, or an alcoholic solution of bi-chloride or biniodide of mercury, and finally loosely packed with a strip of cyanide or sterilised gauze soaked in carbolised glycerine. The dressing should be changed every second or third day until cicatrisation has taken place. After the furuncle has run its course it is advisable to thoroughly sterilise the parts, and to continue for a time antiseptic instillations, for fear of recurrence or the formation of fresh furuncles in other portions of the meatus.

Following the disappearance of the furuncle, there is, for a short period, a cessation of all ceruminous secretion, with the result that a dry, scaly, and irritable condition of the meatus is produced. To relieve this the application of dilute "white precipitate," boracic, or cocaine ointment combined with lanoline and paroleine is advisable, whilst the entrance of water into the meatus whilst washing or bathing is to be carefully avoided.

When furunculosis of the meatus is secondary to chronic suppurative otitis media, attention should be directed to the primary cause, suitable antiseptic treatment being at once instituted.

Under such circumstances it is advisable, as far as is possible, to avoid frequent syringing, and to treat the septic middle ear lesion by the insufflation of antiseptic powders or the introduction of gauze wicks.

General Treatment.—In anaemic and debilitated subjects iron, arsenic, glycero-phosphates, good food, change of air, and occasional laxatives are necessary. In plethoric individuals simple diet, abstinence from alcohol, saline aperients, Turkish baths, and exercise should be enjoined. In diabetes attention to diet, the internal administration of bicarbonate of soda, codeine, or hyoscine, is serviceable. Certain drugs, *e.g.* sulphide and hypophosphite of calcium, malt, and nucleinic acid, are said to possess a specific action in such cases. Brewer's barm or yeast taken internally has attained a certain popular notoriety in the treatment of aural furunculosis.

Auto-vaccine treatment has proved successful in cases of persistent furunculosis, especially when of staphylococcal origin.

5. **Otitis Externa Diffusa.**—Diffuse inflammation of the cutis lining the external auditory meatus is met with in both children and adults, and is characterised by desquamation of epithelial cells, formation of a thin viscid or purulent and at times foetid discharge, and by a varying degree of stenosis. In children a diagnosis of acute otitis externa is frequently made when in reality the case is one of purulent middle ear disease, the swelling and oedema of the walls of the meatus preventing a full view of the membrana tympani.

Aetiology.—The principal causes of diffuse inflammation of the external meatus are the introduction of irritating fluids or solid bodies, bacon, onions, figs, etc., the careless application of caustics, unskilful efforts to extract foreign bodies, and infection from a pre-existing suppurating middle ear, or from the finger, *e.g.* infection by finger from anus. A phlegmonous type of diffuse inflammation has been observed by Politzer and Hessler as the result of excoriation of the cutis of the meatus.

Pathology.—There is generally a foul discharge consisting of scanty granular leucocytes with epidermal scales and bacteria, numerous and variable in type, *e.g. staphylococci, gonococci, bacillus proteus vulgaris, bacillus coli communis,* and *bacillus subtilis.* The process is usually a highly septic and foetid desquamative one, but sometimes distinct ulceration, with a patch of granulation tissue, may be found on clearing out the accumulation.

The gonococcal type, especially in infants, is highly purulent and should always be carefully sought for.

Symptoms.—The symptoms are both objective and subjective. Objectively the deeper portion of the meatus, more especially the osseous meatus, is found blocked by an inspissated mass of debris which, on being syringed out, is found to contain large numbers of epithelial flakes and to swarm with micro-organisms. At times a complete cast of the osseous meatus and outer surface of the membrani tympani may be detached by syringing. The walls of the meatus are often found to be red and inflamed, and to secrete a thin ichorous or viscid secretion. They are at times covered by delicate red and vascular granulations.

The outer surface of the membrana tympani is similarly excoriated and reddened, its normal contour obliterated, and its various landmarks lost to view.

The most important subjective symptom is an intense feeling of irritation, amounting at times to severe pain, slight difficulty in mastication, pulsating tinnitus, and a varying degree of deafness. Deafness, however, is seldom a marked symptom, except in those cases where the meatus is entirely blocked, the membrana tympani greatly swollen, or where there is a concomitant inflammation of the tympanic cavity.

Course.—As a rule the inflammatory process lasts for a few days, and then rapidly subsides. At other times it runs an irregular course, with exacerbations of inflammation. It seldom lapses into actual chronicity.

Prognosis.—The prognosis is, as a rule, quite favourable, except in cases of traumatic origin and gonococcal infection, when the walls of the meatus are at times seriously injured, and when cicatricial occlusion is prone to result. Complete recovery of hearing is usual, except when the inflammatory process has invaded the tympanic cavity. Occasionally, as the result of erosion of the bony walls of the meatus, septic absorption may ensue.

Terminations.—The usual termination is complete recovery. At times the inflammatory process may extend to the tympanum and induce permanent middle ear changes. At other times erosion of the walls of the osseous meatus takes place, followed by the development of exuberant masses of granulation tissue and subsequent formation of cicatricial bands. Atresia of the meatus is only met with in exceptional cases of traumatic origin.

Treatment.—At the commencement of the disease the application of a few leeches around the tragus is followed by marked relief. Heat applied by means of a Leiter's coil apparatus or by the application of pads of wool or spongiopiline is also beneficial. The frequent instillation of a warm solution of acetate of lead and opium affords relief. When discharge takes place the meatus should be gently syringed with a weak antiseptic solution, and insufflations of finely-powdered boracic acid made. Instillations of boracic acid in spirit or glycerine are useful in obstinate cases.

When granulations form the local application of nitrate of silver, pure phenol, or of chromic acid, followed by the instillation of an antiseptic solution, is advisable.

When a tendency to stenosis of the meatus exists the insertion of plugs of wool soaked in acetate of lead solution is frequently beneficial, and in those cases of traumatic origin where complete atresia is present the formation of a fresh meatus, provided that the middle ear is intact, is advisable. In the later stages of the disease the insufflation of such powders as dermatol, aristol, or xeroform is useful.

6. **Otitis Externa Haemorrhagica.**—This form of inflammation is characterised by the appearance of blebs or bullae within the osseous or cartilaginous meatus, more usually the former, or upon the surface of the membrana tympani. They vary in size and number, and present a bluish-black appearance. They are exceedingly soft and fragile, and rupture readily when touched. Spontaneous rupture is also quite common. They are most frequently found upon the inferior and posterior walls of the osseous meatus, and show a tendency to spread deeply towards the membrana tympani, and superficially towards the cartilaginous meatus.

They may result from the too forcible introduction of an aural speculum (Gomperz) or from too forcible suction with a pneumatic speculum, or from irritation of the meatal walls with a pencil, toothpick, etc.

Haemorrhagic extravasations are also frequently met with in cases of influenza. At times there is no apparent cause.

Their formation is ushered in by a feeling of fulness or pain referred to the meatus, tinnitus, and slight deafness. After lasting a few days they disappear spontaneously or rupture with the discharge of a sero-sanguineous fluid. Their disappearance is followed by the desquamation of large epithelial flakes.

Treatment.—Each bulla should be ruptured by pressure with a probe, the fluid contents mopped up with sterile wool, the meatus lightly dusted with pure boracic acid, and a pledget of antiseptic wool inserted. When the bullae are situated upon the surface of the membrana tympani it is advisable to incise each one separately with a sharp paracentesis knife, or they may be let alone to allow of the gradual absorption of their contents.

7. **Spontaneous Haemorrhage from the Auditory Meatus.**—Cases of spontaneous haemorrhage from the auditory meatus have been recorded by S. von Stein,[1] Gradenigo,[2] Goldstein, and others.

In all the recorded cases no abrasion or morbid condition of the external ear was detected, although the fluid, sero-sanguineous in character, could be seen to well up from the depths of the meatus.

In such cases it is essential to examine the ear thoroughly, so as to exclude the presence of organic disease. Spontaneous haemorrhage must not be confounded with the haemorrhage which occurs in the case of malingerers, who either purposely injure the ear or insert blood into the meatus.

Spontaneous haemorrhages into the substance of the tympanic membrane may appear as small bullae just beneath the cutis or in its deeper layers. They retain their red or purple character for as long as three weeks, and gradually disappear by a process of migration, passing from the original point of appearance to the periphery, where they become absorbed. In all such cases the coagulability of the blood should be tested.

When small and uncomplicated they do not give rise to any high degree of deafness, and generally occur in anaemic subjects.

Profuse and troublesome intermittent bleeding accompanies angiomatous growths of the meatus, which are by no means rare. On removal they are found to consist of widely dilated vessels mixed with fibromatous, myxomatous, and sarcomatous elements.

8. **Vicarious Haemorrhage from the Auditory Meatus.** — As vicarious menstruation it occurred in a patient aged thirty-six, who was seen by one of us for intermittent bleeding from the ear of seven months' duration. There was no objective or subjective disease of the ears, the tympanic membranes being perfect. Each attack lasted two or three days, and corresponded with the menstrual flow, which was invariably scanty. It was preceded by a feeling of giddiness, "fulness of the head," but by no deafness. The flow was of a bright arterial colour, lasted for several hours each day, and was accompanied by epistaxis. Although

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[1] *Zeitschrift f. Ohrenheilk.*, 1903.

[2] *Archiv f. Ohren.*, 1889.

the patient was seen several times during the continuance of the haemorrhage its exact source could not be found; there was no doubt, however, of its meatal origin. Treatment was conducted upon general principles for several months, when the bleeding gradually ceased.

The writer has also seen two cases in girls, aged eighteen and twenty-five respectively. In the one a considerable amount of blood was lost each month, in the other haemorrhage from the ears alternated fairly regularly with a menstrual flow.

The regularity of the discharge and the absence of any actual ear disease points to a diagnosis.

Treatment should be conducted upon ordinary gynaecological principles.

9. **Otitis Externa Crouposa.**—Croupous inflammation of the external auditory meatus is characterised by the formation of a tough and homogeneous membrane, limited, according to Politzer, to the bony portion of the meatus and the dermic layer of the membrana tympani. The membrane, although lying in actual contact with the underlying skin, is not adherent to it, and hence is capable of being removed in the form of a cylinder or cast of the parts by means of syringing or with forceps. At first the membranous deposit presents a white appearance, but subsequently assumes a greyish colour. Pathologically it is composed of fibrin, leucocytes, and organisms.

The formation of the membrane is ushered in by deep-seated pain in the ear and by a feeling of fulness with a varying degree of deafness, but with only slight constitutional disturbance. Under suitable treatment the inflammatory process entirely subsides without permanent injury to the auditory apparatus.

Recurrences are, however, somewhat common.

Pathology.—The appearance of a membranous exudate in the meatus is quite as common as in the nose, in fact it usually accompanies the non-specific forms of membranous rhinitis, the infection being probably conveyed by the fingers.

It may appear like the diphtheritic form of exudate in its early stages as a dry, greyish, or white deposit, partially or completely filling the meatus. It is, however, never quite so dry as that found in true diphtheria. It soon becomes softened and readily separated, owing probably to the tryptic bodies formed by the breaking up of leucocytes, which exercise a solvent action upon exudate and epithelium.

It consists like the diphtheritic membrane of coagulated fibrin, entangling leucocytes and desquamated epithelium in its meshes.

Later the epithelial elements become more marked, and the discharge distinctly purulent in character. Just as in acute suppuration of the middle ear, several forms of bacteria may be present, all more or less pyogenic.

Hoffmann's bacillus is very common, together with Friedlander's pneumo-bacillus and Fraenkel's pneumococcus. Gram – diplococci with streptococci and staphylococci are common. In later stages the bacillus pyocyaneus is present, but may only show its colour in cultures.

Prognosis is favourable.

Treatment.—The meatus should be syringed with a weak antiseptic solution of biniodide of mercury (1 to 4000) or phenol (1 per cent), and the membrane removed with an angular pair of forceps.

As it is frequently very tough and plentiful, prolonged irrigation with a solution of sodium sulphate (2 per cent) and sodium bi-borate (0·5 per cent) is necessary for its thorough removal.

Owing to a tendency to the rapid re-formation of exudate the insufflation of powders is better avoided on account of the risk of mechanical blocking of the meatus.

10. **Otitis Externa Diphtheritica** is characterised by the formation of a membranous deposit of a greyish-white appearance closely adherent to the underlying cutis. It may occur as a primary affection, or may be secondary to pharyngeal, naso-pharyngeal, or scarlatinal diphtheria of the fauces and tubo-tympanic tract. When primary it attacks a meatus already excoriated as the result of an otitis externa or repeated attacks of furunculosis, and may be attended with but slight constitutional disturbance.

After removal of the false membrane with forceps the walls of the meatus appear red, bleed easily, and are painful.

Marked stenosis of the meatus is common as the result of swelling and oedema of its walls.

Pathology.—In the early stage a typical diphtheritic dry membrane is present, but later this is replaced by a moist purulent exudate which is easily detached by the probe but rapidly re-forms. As a rule many bacterial forms are present, such as streptococci, diplococci, etc., but the characteristic Klebs-Loeffler bacillus is readily demonstrated, either by direct film or by culture.[1] So long as the discharge persists the specific bacillus is found.

Symptoms.—Primary or secondary diphtheritic inflammation of the walls of the meatus is ushered in by fever, deep-seated pain in the ear, a feeling of fulness, and marked deafness. The glands immediately around the ear become enlarged and tender as well as the chain of glands in the posterior triangle of the neck.

In diphtheria of the meatus secondary to diphtheritic otitis media, there is, according to Wreden, practically no pain.

In primary cases the membranous deposit may be readily thrown off and rapid healing ensue, while in others the process of ulceration may extend deeply, and ultimately lead to considerable cicatricial contraction and deformity.

Diagnosis.—A diagnosis of diphtheria of the meatus is probable if a greyish-white membrane adherent to the walls of the meatus is present, which, on being removed, leaves a raw vascular and readily bleeding surface.

The Klebs-Loeffler bacillus should be sought for, as, if present, the diagnosis is certain.

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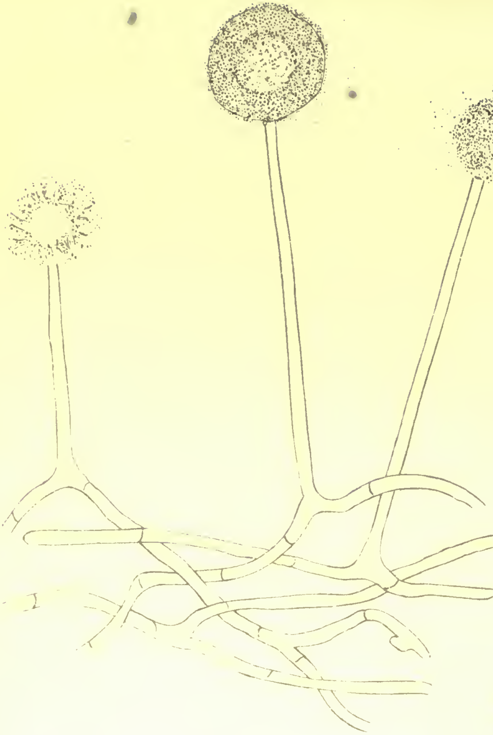
[1] The best stain is 1 per cent solution of methylene violet, with 0·5 per cent of acetic acid, counterstained with ·059 per cent of vesuvin (Neisser).

PLATE II



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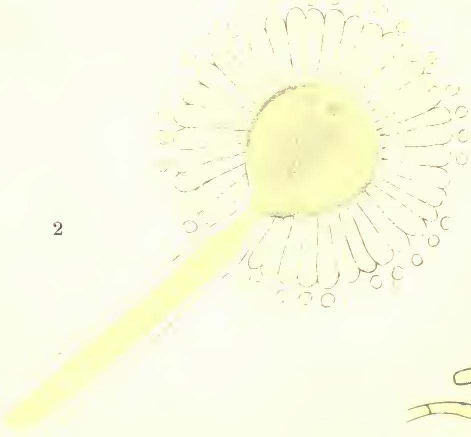

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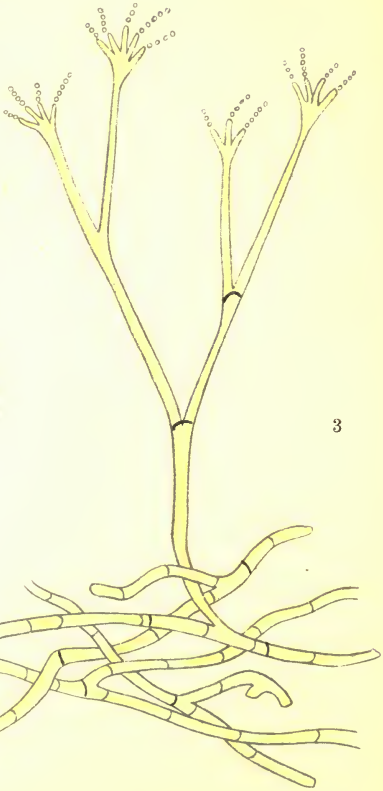

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Fig. 1.—Aspergillus niger. Obj. $\frac{1}{4}$ in.

Fig. 2.—Aspergillus niger—"daisy-like bodies." Obj. $\frac{1}{12}$ in.

Fig. 3.—Penicillium glaucum. Obj. $\frac{1}{12}$ in.

In many cases of scarlatinal otitis media, especially in children, a membranous deposit is found in the meatus, which might readily be mistaken for diphtheria. It, however, peels off easily in large flakes, and leaves a smooth, non-vascular surface behind.

Prognosis.—Primary diphtheria of the meatus runs in most cases an uneventful and favourable course.

Secondary diphtheria of the meatus is, however, a more serious affection, on account of the involvement of the tympanic contents and frequent implication of the internal ear.

Treatment.—Removal of the false membrane appears to exercise very little, if any, effect upon the course of the disease, whilst even if forcibly removed new membrane is almost immediately formed.

Its separation may, however, be accelerated by the instillation of warm solutions of lime water (Burckhardt Merian, Gottstein).

The instillation of solutions of boracic acid (1 to 20), glycerine of carbolic acid (1 to 4), or perchloride of mercury (1 to 2000) is beneficial.

After detachment or exfoliation of the membranous deposit the raw surface should be dusted with boracic, xeroform, or iodol powder.

In addition to local treatment injections of antitoxin should be given in doses commensurate with the toxicity of the general infection, while stimulants, tonics, and nourishing food are indicated.

11. **Otitis Externa Parasitica** (*Otomycosis*).—The presence of fungi in the auditory meatus is invariably associated with a mild form of inflammatory irritation, rarely extending to more than epidermal exfoliation and slight eczematous exudation, since the chief variety—the *aspergillus niger*—will not grow when true pus is present, *i.e.* a profuse discharge containing active leucocytes.

It is not as common in England as in hot countries and continental cities, and is certainly not of such frequent occurrence in this country as many text-books suggest. In Egypt and India it is by no means rare, and a large proportion of private patients can trace their infection to these and other tropical countries. It may occur at any age, and is not confined to the poorer classes, while it is generally found in those who have suffered from some lesion of the middle or external ear; but it is just as frequently found in those who can adduce no evidence or history of any ear trouble. The most important predisposing causes are *otitis externa diffusa* and residence or occupation in unhealthy surroundings.

The fungi most frequently met with are *aspergillus niger*, *flavus* or *fumigatus*. The fungus is not easily seen by the naked eye. All grey mottled spots like wet blotting-paper are not necessarily aspergillosis, since they may be due to carbon particles or to the use of lead drops. If gently teased out in normal saline fluid felted masses of filaments or segmented mycelia are easily recognised, from which spring straight hyphae terminated by "daisy"-like bodies, varying in colour from a pale yellow to a dark brown the striking character of *aspergillus niger* (Plate II.).

The parasites are, as a rule, met with in the bony portions of the auditory meatus and upon the external surface of the membrana tympani.

Symptoms.—The symptoms vary according to whether the growth is purely superficial or within the deeper layers of the meatal lining.

In the former no symptoms may present themselves, the affection being discovered purely accidentally; in the latter intolerable itching but rarely severe pain are complained of. Discharge is scanty.

Obstruction of the meatus with deafness and constant tinnitus may occasionally be present. Severe vertigo has been observed by Bronner[1] in the case of an adult male aged fifty-five. There may be a slight moisture or watery discharge, but no pus.

Inspection reveals the deeper portions of the meatus and at times the outer surface of the membrana tympani covered with a smooth opaque and granular deposit, not inaptly compared to chewed paper, the actual colour varying with the particular fungus which is present. It is, in fact, a maceration of the cutis.

When no inflammatory reaction has taken place small clusters of fungi may be seen at times with the naked eye, at other times with the aid of a magnifying ear-speculum.

When, on the other hand, an otitis externa co-exists, the cells of the cutis desquamate, exposing islets of superficial denudation surrounded by colonies of fungous growth. In more severe cases fungi may penetrate the tissues still more deeply, and in a case recorded by Haug were found to have actually entered the cells of the mastoid process. Perforation of the membrana tympani from without is also not uncommon, when occurring as a sequel to middle-ear disease.

Diagnosis.—The history of the case in conjunction with the appearances presented by objective examination are, as a rule, quite sufficient to establish a diagnosis. In doubtful cases it is necessary to resort to microscopic examination in order to distinguish between fungous growth, desquamated epithelium, inspissated pus, and various atmospheric impurities.

Prognosis.—The prognosis is, as a rule, quite favourable, provided, in the first place, that suitable local treatment be employed, and in the second place that due attention is paid to the character of the patient's surroundings.

In those cases where perforation of the membrana tympani has taken place, cicatrisation rapidly ensues under appropriate treatment. In exceptional cases relapses may take place, notwithstanding the fact that the patient may be living under perfectly hygienic conditions, because the spores have not been killed. Recurrence may happen many months after apparently complete cure.

Treatment.—Attention to any particular circumstance, general or local, favourable to the development of fungous growths, is requisite. Thus removal from damp, ill-lighted, and ill-ventilated apartments is essential.

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[1] *Trans. Otolog. Soc.* vii. 14.

The local use of antiseptic and anti-parasitic remedies is attended by excellent results.

The instillation of a 1 per cent solution of salicylic acid in rectified spirit followed by irrigation with ½ per cent solution of borax will effectually soften and remove the fungus and epithelium. This should be followed by the instillation of alcoholic solutions of bi-chloride or biniodide of mercury, or saturated alcoholic solutions of boracic acid, or a 1 per cent alcoholic solution of salicylic acid or formaline.

Insufflations of finely-powdered boracic acid, iodoform and boracic acid (1 to 4), zinc oxide and boracic acid (Theobald), dermatol, or xeroform powders are at times valuable when eczema is present.

Any coincidental affection of the external or middle ear is to be treated upon general principles.

To prevent recurrence it is advisable for the patient to employ from time to time one or other of the above-mentioned lotions, owing to the difficulty of killing every spore.

12. OSSEOUS TUMOURS IN THE EXTERNAL AUDITORY MEATUS

Osseous tumours occurring in the external auditory meatus may be pedunculated or sessile, single or multiple, and may be situated at the junction of the bony with the cartilaginous meatus, several millimetres from the membrane, or in the depths of the meatus close to the tympanum.

They are more frequently met with in men, especially amongst those who live well, than in women. A gouty or rheumatic diathesis is said to be a predisposing cause, as also is a history of syphilis. They are also met with amongst those who bathe frequently, *e.g.* South Sea Islanders, the entrance of sea water at varying temperatures and pressure apparently contributing to their formation. They also occur as the outcome of ulceration of the soft tissues of the auditory meatus and middle ear. The small osseous growths frequently met with in the meatus close to the attachment of the membrana tympani are probably congenital in origin, and occur during the process of ossification of the annulus tympanicus.

Heredity is also said to play a prominent part in their aetiology. As the outcome of irritation of the walls of the auditory meatus, the result of chronic purulent otitis media or chronic purulent disease of the mastoid cells, a diffuse thickening (hyperostosis) of the posterior meatal wall may take place with subsequent formation of bone. As a rule the rate of growth is extremely slow, and may become interrupted or may be intermittent. A marked tendency to active growth has been observed in women after parturition.

Pathology.—Osseous tumours of the meatus are of two kinds, eburnated or ivory, and spongy or cancellous, a distinction which if feasible before operating would save much inconvenience.

They are further described as exostoses and hyperostoses, a distinction which is not of much practical value since it is not often difficult to establish. Exostoses may be viewed as circumscribed sessile or pedunculated bony tumours, while hyperostoses are more flattened and diffused thickenings of the bone.

The cancellous type, whether occurring as a prominent exostosis or as a flattened hyperostosis, is formed by a process of osseous hyperplasia from the periosteum of developed bone due to long-continued inflammatory and other forms of irritation.

Ivory exostoses, on the other hand, are formed by eccentric ossification in developing bone quite apart from any local inflammation.

Cancellous exostoses may be said to be almost invariably associated at some period of their growth with disease and discharge from adjacent structures.

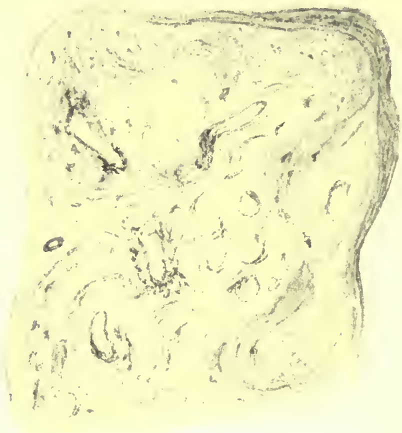

FIG. 80.—Ivory exostosis from tympanic bone. Obj. ½ in.

The ivory form is restricted in its origin and attachment to the tympanic element, and is thus formed in membrane, the petro-mastoid or periotic—formed from cartilage—being free from them.

In the Toynbee collection of nine specimens of bony growths of the meatus, eight are situated on the posterior wall, and one on the anterior. Two of those growing from the posterior wall involved the floor of the meatus by extension.

As a rule they are firmly fixed, but in a few instances some slight mobility has been recorded owing to a thin layer of periosteal fibrous tissue separating them from the subjacent bone.

With regard to their pathology it has been suggested that they are formed by metaplastic bone formation from granulation tissue itself. Such, however, is extremely doubtful, and although they may be found partially embedded in polypoid tissue their real origin is from the adjacent periosteum.

In structure the ivory type consists of a compact calcified matrix containing lacunae and canaliculi, disposed irregularly, unlike the regular concentric grouping of ordinary compact bone around the Haversian canals. Instead of possessing the latter, vascular canals pierce the matrix from the surface similar to the Volkmann's canal of normal subperiosteal lamellae, from which their nourishment is mainly supplied. If quiescent they are covered by a thin layer of highly vascular periosteum with flattened osteoblasts, but if still growing their cells are numerous, large, and spheroidal (Fig. 80).

Cancellous exostoses are composed of true but often deformed

Haversian systems with large medullary spaces containing blood-vessels and osteoblasts. They are very vascular and bleed freely on removal. Their periosteum is thick and highly vascular, and is lined by one or more rows of large active osteoblasts (Fig. 81).

The congenital or eburnated variety is often symmetrically distributed, but the cancellous is only so when both ears are, or have been, subject to other forms of disease.

Symptoms.—Exostoses of the meatus appear as rounded, smooth, and glistening tumours, of varying size and number, and often tender on probing. Occasionally their surface is ulcerated from contact pressure and covered with minute vascular granulations, and attended by discharge. When single and sessile the growths may occupy the whole lumen of the meatus and lie in contact with the opposite wall.

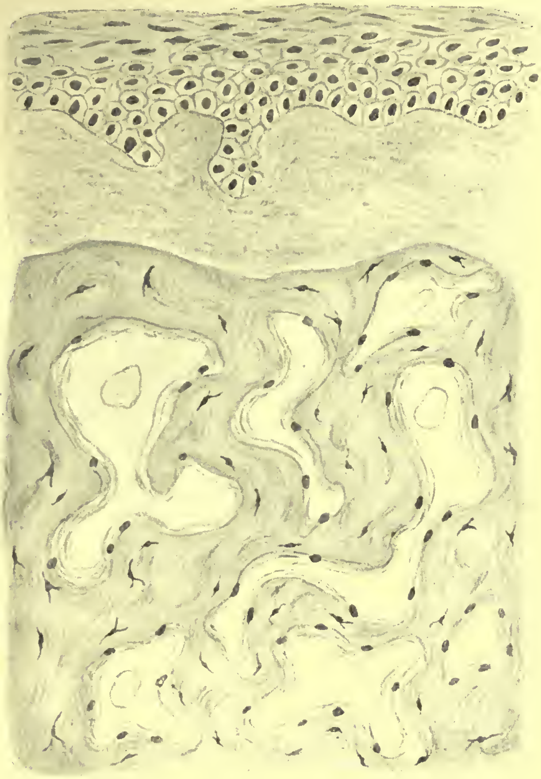

Fig. 81.—Cancellous exostosis of meatus. Obj. ⅛ in.

Multiple exostoses are frequently met with, and are so situated as to leave only a narrow chink between them, through which it is not always possible to obtain a view of the membrana tympani.

Such multiple exostoses may be bilateral and occasionally symmetrical.

The various symptoms associated with their presence are due not so much to the existence of the exostoses as to an accompanying inflammation of the walls of the meatus or lining membrane of the middle ear. When of such size as to occlude the lumen of the meatus high grades of deafness are common. Sudden deafness also frequently supervenes from impaction of cerumen or epithelial debris behind the bony growths, accompanied by tinnitus, and in some cases by vertigo.

When in actual contact with one another or with the opposite wall of the meatus painful ulceration, accompanied by discharge, may result. Trigeminal neuralgia has also been noted in some cases. On the other hand, small exostoses may give rise to no symptoms, and may only be discovered casually.

FIG. 82.—Cancellous exostosis. Obj. $\frac{1}{2}$ in.

When associated with purulent middle-ear disease urgent symptoms may supervene at any moment, from blocking of the canal and retention of secretion. Their presence under such circumstances is always a menace to the patient, and their immediate removal, especially if of large size, is urgently called for. In a case seen by the writer, where large symmetrical hyperostoses existed associated with very chronic purulent middle-ear disease, and where immediate operation was advised but declined, death took place a few weeks later from diffuse suppurative basal meningitis.

Diagnosis.—The presence of smooth, pale, globular swellings, tender to touch, and imparting to the probe a feeling of great resistance, is sufficient to render the diagnosis a matter of no difficulty. If inflamed and ulcerated, and especially if covered with vascular granulation tissue, the appearances presented simulate those of polypi, but if carefully probed the resistance offered is sufficient to prevent any mistake.

Treatment.—From the fact that many exostoses are discovered purely accidentally, and also because in many cases no symptoms are ever complained of, no treatment beyond an inspection of the ear at intervals and testing of the hearing power is called for. On the other hand, when the lumen of the meatus is almost entirely blocked, and especially when middle-ear suppuration is present, removal of the growth is demanded. Before any operative interference is undertaken the condition of the middle and internal ears should be carefully investigated, as if their mechanism be already seriously interfered with, the removal of an exostosis will have little if any effect upon audition.

In many cases all that is required is cleansing of the meatus to prevent the occurrence of sudden deafness from impaction of cerumen behind the osseous growth or growths. To effect this several instillations of a 1 per cent solution of caustic potash in glycerine should be made, followed by the use of a fine cannula attached to a syringe to wash out the accumulated mass. The cannula should be passed through the narrow chink and beyond the narrow growth under illumination from a forehead mirror.

This method of cleansing repeated once or twice a year is often all that is required. When the growth is large and is seriously and permanently interfering with audition, or when a suppurative otitis media is present, dilatation of the passage or removal of the exostosis is demanded. The insertion of a thin metal plug or laminaria tent between the growth and the meatal wall, or between the several exostoses, should two or more be present, is at times all that is required to dilate the meatus sufficiently to admit of the passage of sound waves to the membrana tympani, and to prevent the frequent accumulation of cerumen.

The presence of a hard ceruminous plug induces at times an amount of superficial ulceration, which by subsequent contraction leads to a considerable dilatation of the lumen of the meatus.

Operative removal of an exostosis is indicated under the following conditions:—

1. When the meatus is completely occluded with a resulting high degree of deafness, and where at the same time the opposite ear is affected.
2. In cases when, as the result of contact pressure, ulceration, accompanied by severe pain, is complained of.
3. When recurring attacks of otitis externa diffusa are frequent.
4. When there is a co-existing suppurative otitis media.
5. When the exostosis is growing.

Pedunculated exostoses are at times easily removed by means of a hammer and small chisel, especially if situated comparatively superficially. In suitable cases the passage of a wire loop over the growth and the encircling of its pedicle may, if sufficient traction be made, be sufficient to wrench the growth from its point of attachment. Instead of the cold wire loop a cautery snare may be employed.

When two or more exostoses exist, leaving a narrow space between them, a small bur driven by a foot- or electro-motor may be employed to grind the bone away, or a small passage may be burred through the base of each growth and enlarged by the use of larger and larger burs until the growths are cut away. The greatest objection to the use of the bur is the danger of its slipping and perforating the membrana tympani and so injuring the contents of the middle ear.

When the exostosis is single and sessile the following method has proved successful:—

First produce local anaesthesia and ischaemia by instillation of 20 per cent solution of cocaine hydrochloride with equal parts of adrenalin solution (1 to 1000). Vertically incise the soft tissues covering the exostosis and completely remove the periosteum with a small raspatory or curette. Stop all bleeding. Then with a small trephine (from 2 to 5 mm. in diameter according to the size of the growth), driven by an electric motor, cut through the base in two places if necessary. The exostosis, however hard, is thus rapidly and painlessly pierced; and may be removed by forceps. This method avoids all bleeding, which often materially interferes with the operation, and is preferable to the use of drills, burs, or chisels, which, should the exostosis prove to be of the ivory type, entails a much longer operation.

It is wise to look upon every exostosis as an "ivory" exostosis before operating whenever there is any doubt as to its probable consistence, and to select the *modus operandi* suitable to the hardest type.

In several cases in which the writer has employed this method of treatment, sometimes with and sometimes without a steel guard, the results have been satisfactory. The manipulation of the steel guard is always, however, a matter of great difficulty, and any security it may apparently afford is hardly compensated for by the room it takes up.

Haemorrhage, which is at times troublesome, may be controlled by frequent syringing with hot sterile water or by the instillation of adrenalin solution. If the bur be worked very rapidly the heat generated is capable of coagulating the blood (Dalby). Sessile osseous growths with broad bases are best removed by means of hammer and chisel with or without the throwing forward of the external ear. The advantage of throwing forward the auricle and detaching the cartilaginous meatus is that the osseous growth is brought much more fully into view, and that that portion of the bony meatus lying immediately under the exostosis can be removed at the same time, a procedure which materially simplifies the operation.

To throw forward the external ear an incision of from 1 to 1¼ inches is made ¼ inch behind and parallel to the attachment of the auricle. The soft tissues and periosteum are then reflected until the posterior wall of the cartilaginous meatus is fully exposed. All bleeding having been arrested, the cartilaginous meatus is separated from its attachment to the posterior border of the osseous meatus, and, with the auricle, is drawn forwards so as to fully expose the osseous growth.

After removal of the exostosis the auricle is replaced and the incision sewn up when union by primary intention takes place. The raw, bony surface should be dusted with boracic or iodoform powder and the meatus lightly plugged with sterilised gauze.

Should suppuration take place, syringing with antiseptics and the instillation of a solution of boracic acid and spirit, glycerine of carbolic acid (4 per cent), or hydrogen peroxide is indicated.

When it is necessary to remove a considerable portion of the posterior osseous wall, it is advisable to split the cartilaginous meatus through the centre of its posterior wall and to fold the flaps upwards and downwards, keeping them in position by means of packing or by the insertion of one or two stitches.

13. STRICTURE OF THE EXTERNAL AUDITORY MEATUS

The external auditory meatus may become markedly stenosed as the result of inflammation and thickening of the cuticular, subcutaneous, perichondrial, or periosteal lining of its walls, or from the formation of hyperostoses or exostoses.

In elderly and edentulous people the walls of the meatus may collapse from atrophy of their osseous, fibrous, and cartilaginous elements, so that the meatus assumes a narrow slit-like shape.

As the outcome of traumatism and subsequent cicatricial contraction, adhesions of various size, shape, and form may result, which produce considerable stenosis of the meatus, and at times its complete occlusion.

In cases where a complete post-aural operation has been performed, and when the flaps fashioned from the soft tissues have not been sufficiently carefully cut or maintained in position, stenosis of the meatus is prone to occur.

Ulceration of the meatal walls, whether of syphilitic, diphtheritic, or traumatic origin, is also prone to be followed by stenosis. In infants and young children the wearing of unsuitable headgear, or the too forcible bandaging of the auricle to the side of the head, is prone to lead to collapse of the meatal walls and narrowing of the external auditory canal.

Chronic suppurative middle-ear disease, chronic furunculosis, eczema (Moos), and otitis externa diffusa are also prone to lead to deep-seated changes in the cutis and fibro-periosteum, ending in partial or complete obliteration of the external auditory meatus.

Another and not infrequent cause is the cicatricial contraction which follows the formation and exfoliation of mastoid sequestra.

Those strictures which are due to more or less superficial inflammatory changes in the cutis frequently disappear under suitable antiphlogistic treatment, while those in which a definite connective-tissue hyperplasia has taken place tend to remain permanent. The actual site and shape of the stricture varies considerably. Strictures due to ulceration of the walls of the meatus, or to injury from the careless application of chemical caustics or the galvano-cautery, are fairly localised, and tend to assume a more or less circular shape, so diminishing the lumen of the meatus as to render an examination of the membrana tympani a matter of the greatest difficulty. Retention of secretion behind such annular strictures leads frequently to the onset of sudden deafness, often due to the effect of syringing or the action of drops upon an epidermal plug beyond the stricture, and at times to urgent febrile symptoms. The size, shape, and extent of a stricture due to osseous occlusion of the meatus varies with the amount of new bone formed. Where two exostoses are present an hour-glass slit may result; when there are more than two the meatus may be so narrowed as to hardly admit a fine probe. With the aid of a blunt probe the length and consistence of a stricture may, as a rule, be estimated.

Very marked constriction of the meatus frequently follows periostitis of the posterior meatal wall the result of mastoid suppuration (Fig. 83). Sequestra of varying size may become exfoliated with resulting cicatricial contraction, or extensive formation of new bone may take place.

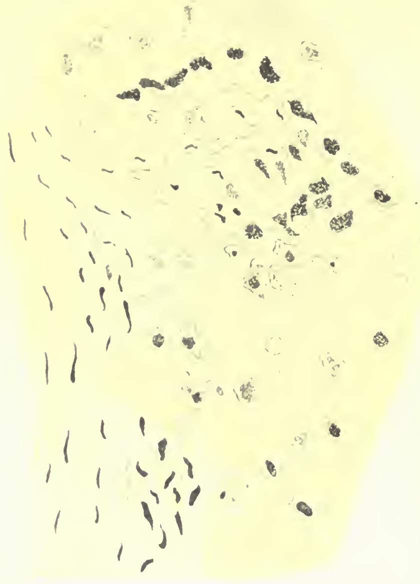

FIG. 83. Periostitis of temporal bone (chronic). Obj. ⅛ in.

Treatment.—The treatment of stricture of the meatus will necessarily depend upon its immediate causation, and whether it be cuticular, fibrous, or bony.

Strictures due to inflammatory thickening of the soft tissues of the meatus, especially if of recent origin, are fairly amenable to antiphlogistic and sedative treatment. If of older standing and consequently mainly fibrous, mechanical dilatation should be practised. For this purpose cylinders of compressed cotton wool soaked in acetate of lead solution or sterile vaseline are useful, the pressure exerted causing a gradual dilatation of the stenosed area. Compressed sponge tents and laminaria tents may also be employed. During their introduction great care should be taken not to injure the epithelium of the meatal walls, as otherwise raw surfaces are produced which tend to adhere and to cause still farther contraction. The pain produced by the gradual expansion of a laminaria or a sponge tent is at times so severe as to necessitate the employment of sedatives.

Instead of sponge tents, metal tubes or plugs of varying size may be employed. In favourable cases it is at times possible to excise the stricture. This applies more particularly to annular strictures and to those situated near the orifice of the auditory meatus. In certain other cases it is advisable to detach the auricle and throw it forwards, when the stricture, being much more visible, is more easily dissected out.

Osseous strictures due to the presence of exostoses demand the treatment applicable to the removal of exostoses (p. 141), whilst if due to the existence of hyperostosis of the posterior meatal wall, it is, as a rule, advisable to perform a post-aural operation.

Where suppuration is present behind the stricture active treatment is indicated, otherwise all that is necessary is from time to time to remove ceruminous or epithelial collections to prevent the onset of deafness.

In cases of occlusion from senile degeneration of the cartilaginous walls of the meatus the wearing of a thin, cone-shaped, gold, or celluloid tube affords relief.

14. CARIES AND NECROSIS OF THE EXTERNAL MEATUS

Caries or necrosis of the bony walls of the auditory meatus results usually as the consequence of chronic purulent otitis media with or without involvement of the contiguous mastoid cells.

At other times diffuse inflammation of the walls of the meatus leads to suppurative periostitis which in turn leads to exposure or death of the underlying bone.

The pressure of a mass of cholesteatomatous debris or the presence of a neglected furuncle are also at times proximate causes.

When due to mastoid suppuration the posterior or superior wall of the meatus is affected. By palpation with a probe a minute fistulous tract surmounted by a delicate fringe of granulation tissue may be found leading deeply into the mastoid cells. When resulting from diffuse inflammation of the meatal walls the swelling of the soft tissues may be so great as to produce considerable stenosis of the meatus.

Pathology.—Caries of the osseous meatal boundary is usually the result of chronic inflammatory changes extending from the antro-tympanic cavity in which tubercle plays a very prominent part. It may also be due to streptothricial infection, to syphilis, and to malignant neoplasms. Farther, it has been associated with acute periostitis (traumatic) and with glycosuria.

Necrosis, marked by exfoliation, may occur as a sequel to acute osteomyelitis or to syphilitic changes involving the dense bone.

That caries of this region is so frequently associated with chronic antro-tympanic suppuration is not surprising owing to the accumulation of pus in the adjacent pneumatic spaces, whose tryptic products rapidly cause erosion and absorption of the bony walls.

Symptoms.—The symptoms vary with the underlying cause. Where a sequestrum is in process of formation there is, as a rule, considerable pain and at times difficulty in mastication. The accompanying discharge is usually foetid and blood-stained.

The degree of deafness varies with the nature and extent of the co-existing middle ear disease and with the amount of stenosis of the meatus which is present.

Diagnosis.—A definite diagnosis is made by means of careful probing. Caries is indicated by the presence of a patch of softened bone or of a fistula leading into the mastoid cells; necrosis by the presence of a sequestrum, movable or detached.

The presence also of a cutaneous ulcer encircled by a fringe of exuberant granulations is highly suggestive of dead bone, as also is a localised swelling of the meatal walls surmounted by granulation tissue.

Treatment.—The treatment to be adopted depends upon the underlying cause. Thus if middle-ear suppuration be present it should be treated upon ordinary principles (Chap. XVIII.). When the wall of the auditory meatus is swollen and soft it should be incised, and the underlying carious patch scraped or treated with dilute mineral acid lotions. When a fistulous tract leads into the mastoid cells a complete post-aural operation is, as a rule, indicated (p. 323).

Sequestra should be removed when loose and detachable. If partially fixed they may be broken up by suitable forceps or antiseptic treatment instituted until separation takes place.

After removal of the sequestrum or scraping of the carious area the use of antiseptic lotions, or the insufflation of antiseptic powders is indicated.

CHAPTER XI

THE MIDDLE EAR OR TYMPANUM

ANATOMICALLY and physiologically this cavity includes the antro-tympanic chambers with the canal of the Eustachian tube, the whole forming the middle-ear cleft (Figs. 85 and 86). It is, in fact, the hypo-

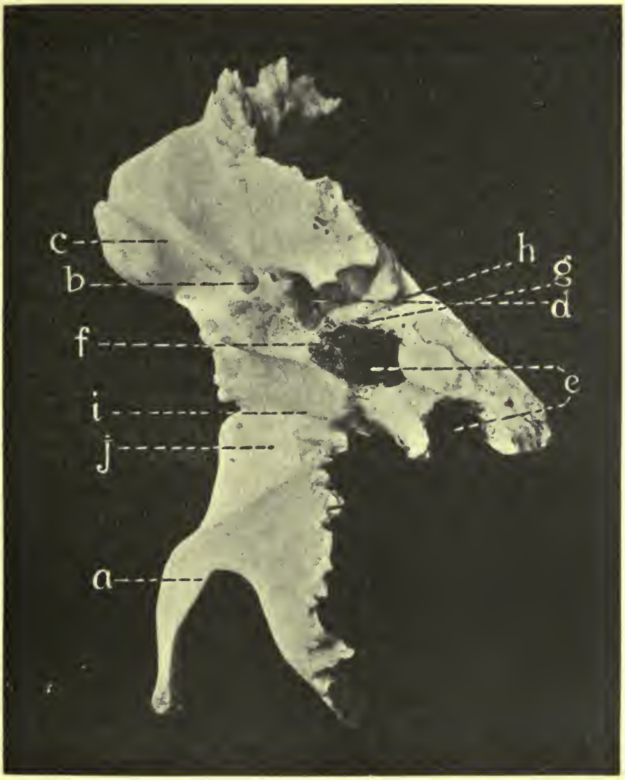

FIG. 84.—Temporal bone (adult male), viewed from below. *a*, Zygomatic process; *b*, stylo-mastoid foramen; *c*, digastric groove; *d*, jugular fossa; *e*, carotid canal; *f*, base of styloid process (broken off); *g*, opening in bone for auricular nerve; *h*, aqueductus cochleae; *i*, Glaserian fissure; *j*, glenoid fossa.

blastic portion of the aural cleft. For surgical purposes, it is advisable to treat it as one continuous cavity although, for convenience of description, the tympanum proper, the mastoid antrum, and the Eustachian tube will be dealt with separately.

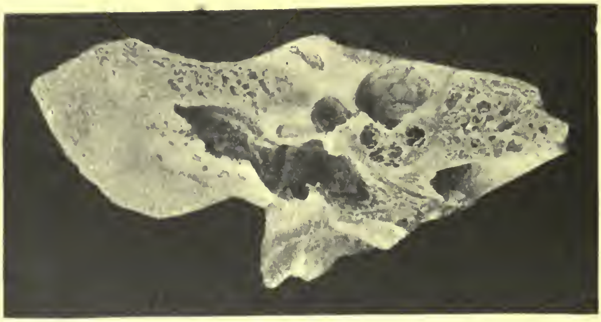

FIG. 85.—Horizontal section of the temporal bone showing the middle ear cleft and its relation to the cochlea.

The walls of the tympanum, although on the whole much smoother than those of the antral chamber, are in parts honey-combed by pits or depressions of variable size and depth. These pits or tympanic cells are pneumatic, and are lined by a membrane common to the general cavity They are often well marked just below the pars promontoria.

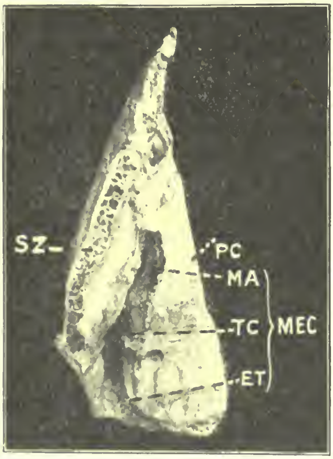

FIG. 86.—Temporal bone showing the "middle ear cleft." SZ, Squamo-zygomatic portion of temporal bone; MA, mastoid antrum; TC, tympanic cavity; ET, Eustachian tube; PC, posterior semicircular canal.

The tympanum proper is an irregularly-shaped chamber, enclosed in the petro-squamosal bone, with supplementary compartments formed in the mastoid element, which separates it from the jugular floor, and so completes the bony chamber. It is very narrow, owing to the inclination of its inner and outer walls.

The *roof* or tegmen tympani is formed by the antero-superior surface of the petrous bone, having the petro-squamosal fissure externally, and internally a fissure leading to the hiatus Fallopii. It consists of three parts, the *tegmen tubae*, the *tegmen tympani*, and the *tegmen antri*, covering respectively the tube, the cavity of the tympanum proper, and the antrum. It is somewhat rough in parts, particularly over the antrum, and forms but a thin partition between the cavity of the middle ear and the middle cranial fossa perforated by minute apertures for veins to the superior petrosal and the sigmoid sinus.

The *floor* is narrow and ill-defined owing to the downward inclination of its boundaries. It is separated from the lateral part of the jugular fossa by a thin plate of bone pierced by an aperture for the entrance of the tympanic nerve. The *outer wall* consists of two parts, a relatively small upper or epitympanic portion, formed by the squama and containing cell spaces which overhang the meatus, and a lower formed by the tympanic membrane, inserted into the grooved margin of the tympanic ring.

Anterior to this is the Glaserian or petro-tympanic fissure, adjoining the *iter chordae anterius*, for the exit of the chorda tympani nerve. The Glaserian fissure is additionally interesting from its association with the following structures:

(1) Tympanic branch of internal maxillary artery.
(2) A bony lamella from the cochlear process.
(3) The anterior ligament of the malleus.

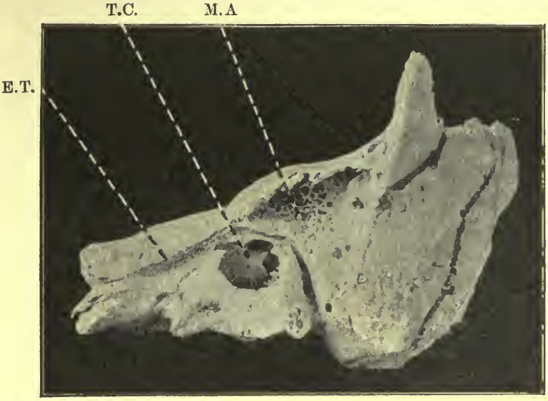

Fig. 87.—Temporal bone showing the continuity of the cavities of the middle ear. E.T., Eustachian tube; T.C., tympanic cavity; M.A., mastoid antrum.

Above the ring is a notch, the *incisura Rivini*, while in front of and behind it are seen the anterior and posterior tympanic spines.

The *tympanic membrane* is an irregularly shaped oval disc, measuring about 10 × 9 millimetres at all ages. It is placed obliquely, inclining towards the anterior and lower part of the meatus, at an angle of about 50° (Fig. 6). The two membranes converge anteriorly, so that if prolonged they would meet to form an angle of about 135°. It is translucent, somewhat dry externally, and although highly elastic is sufficiently rigid to retain its characteristic shape and contour after removal from its attachments. It is not flat, but owing to its structure and attachments presents an outward concavity and an inward convexity, the deepest part of the depression being the *umbo* which corresponds with the tip of the malleus. From this point to the periphery, the anterior and inferior quadrants show a curvature with an external convexity, which is much flatter in the posterior half. Tracing the handle of the malleus upwards and forwards, leads to a pointed projection, indicating the *processus brevis*, passing from which two folds or thicknesses of the membrane are seen, more especially when it is indrawn. They are connected with the anterior and posterior tympanic spines. Above these folds the tympanic membrane is thinner, less tense, and is called the *membrana flaccida Shrapnelli.* It is attached above to the notch of Rivini and so forms the outer wall of Prussak's space, seen from the exterior as a distinct pit or depression.

The tympanic membrane consists of three distinct layers, an outer or cuticular continuous with the meatus, a fibro-elastic or membrana propria, and an internal, often questionably called its mucous layer. Histologically from without inwards it presents the following details:

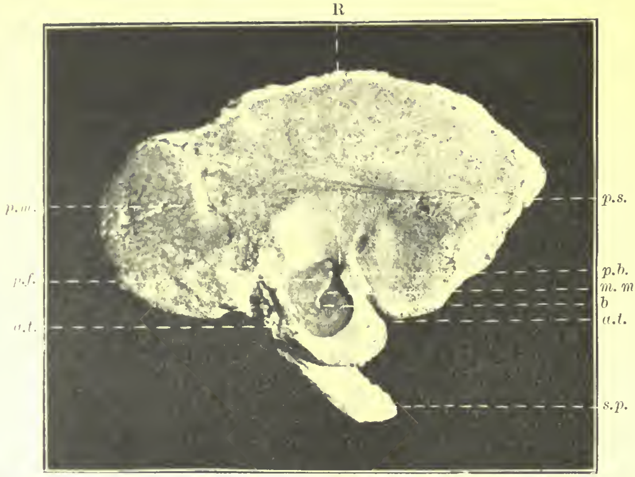

Fig. 88. Temporal bone from a child aged 2 years, showing attachment and plane of membrana tympani. *p.s.*, pars squamosa; *p.b.*, processus brevis; *m.m.*, manubrium mallei; *b*, umbo; *a.t.*, annulus tympanicus; *s.p.*, styloid process; *p.m.*, pars mastoidea; *p.f.*, posterior fold; R, notch of Rivini.

1. A very thin layer of non-nucleated squames, representing the stratum corneum of the epiderm, underneath which are five or six layers of nucleated Malpighian cells, the deepest being columnar. It is especially thick over the malleal ring and at the umbo.

2. Next occurs a loose or reticular layer of fine interlacing connective tissue fibres supporting blood-vessels and nerves. This, unlike the inner lining, is somewhat loosely constructed and is the usual site of haemorrhages, effusions, and ecchymoses.

3. The middle layer consists of closely packed fibres of white connective tissue, mingled with a few elastic fibres, arranged in two sets—an external which radiates from the malleus, and a more internal or circular. The latter is chiefly marked at the periphery of the membrane where, combining with the radiating set, it forms a thick ligamentous ring, the *annulus fibrosus*, which is inserted into the bony *sulcus tym-*

panicus. On the inner or mesial aspect of the membrane there are additional fibres which form loose interlacing bundles through which the blood-vessels of the meatus and tympanic cavity anastomose. Special thickenings, the anterior and posterior tympano-malleolar folds, have already been referred to. These strands are said to be continuous with others which pass across portions of the tympanic cavity, and are doubtless vestiges of the embryonic tissue which originally filled the middle ear. Over Shrapnell's membrane, filling in the notch of Rivini, only circular fibres are present.

4. The internal or tympanic lining is intimately attached to the circular fibres of the membrana propria, being separated from them by a very thin reticular layer containing blood-vessels. It is covered by non-ciliated epithelium, which is cubical in early but flattened in adult life. This surface is not so smooth as the cuticular and during infancy villous projections containing capillaries have been described.

Arterial Supply of the Tympanic Membrane.—Blood-vessels are derived from two sources. Cuticular, by a small branch of the deep auricular, from the internal maxillary artery, which reaches the membrane along the handle of the malleus, and forms a fine capillary zone at the margin of the membrane. From the tympanic lining, a rich plexus of vessels passes through the reticular spaces of the substantia propria to both the central and peripheral areas. Anastomosis between these two sources of supply is thus free. Lymphatics and veins follow the course of the arteries.

Nerve Supply.—Like the arterial, the nerve supply is from two sources. The cuticular aspect is supplied by the auriculo-temporal branch of the fifth which supplies its upper portion, while its lowermost part is supplied by the auricular branch of the vagus.

The inner or tympanic aspect receives its sensation from the tympanic plexus.

Relation of the Tympanic Membrane to the Inner Wall of the Tympanum.—This is of importance, not only in view of operations on the membrane itself and the structures in the tympanic cavity, but also on account of the pathological lesions which affect this region. Although the distance between the membrane and the inner wall may vary considerably, it is never very great, averaging about 2 mm. at the point of nearest approximation—between the umbo and the promontory. The space between the posterior inferior quadrant and the inner wall according to Schwartze, is greater, varying from 2·5 mm. to 4 mm.

The posterior superior quadrant is distant from the malleo-incudal joint which may be visible behind the malleal handle in cases of perforation of that segment about 2 to 3 mm.

The anterior half of the membrane is directly opposite to the large Eustachian ostium in children, but more distant in the adult. The position of the carotid canal and of the jugular fossa below should not be forgotten.

The inner wall, the most interesting and also the most important boundary of the tympanum, may be seen from the cranial aspect by removing the tegmen tympani, from below by chipping away the tympanic plate, and from outside by removing the structures essential to a complete Stacke's operation. Although for the most part smooth, it is marked by several irregularities of surface, or landmarks. Above and posteriorly is seen an oval or reniform aperture, the *fenestra ovalis* or *fenestra vestibuli*, which, in the recent state is filled by a membrane on which rests the stapes. It is approached by a shallow depression, the fossula ovalis (Fig. 89).

Immediately above this window and close to the tegmen is a well-defined ridge (occasionally dehiscent) the Fallopian aqueduct, containing the facial nerve in its backward course, while higher still and somewhat posteriorly, is another ridge indicating the horizontal or external semicircular canal. Below it is a smooth rounded elevation (marked by grooves for the tympanic plexus) the promontory which is formed by the first turn of the cochlea.

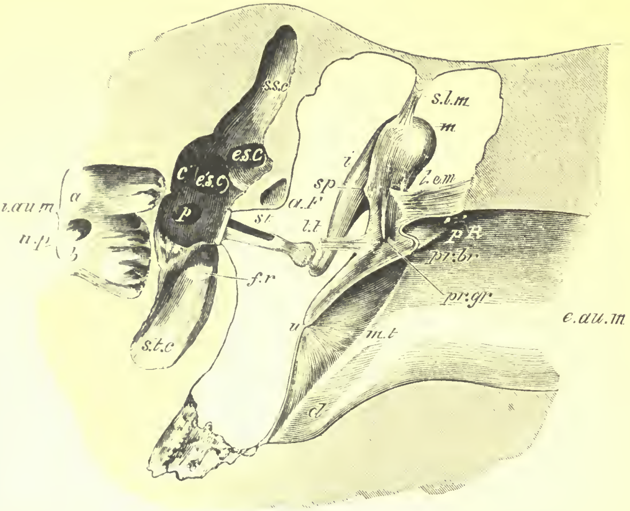

FIG. 89. Vertical section through tympanic cavity (diagrammatic). *PR*, Notch of Rivinus; *d*, membrano-meatal fossa; *n.p*, canal for nerve to posterior semicircular canal (for. sing.); *p*, ampulla of posterior semicircular canal; *a*.F, aqueduct of Fallopius.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

Below and behind the promontory will be seen a small depression, the opening of a hood-shaped tunnel, the *fossula rotunda*, which leads to another labyrinthine aperture, the *fenestra rotunda* or *fenestra cochleae*, which in the recent state is filled with the *membrana secundaria* of Scarpa (Fig. 90). This membrane, like the tympanic, is composed of three layers—an external or epithelial, a middle or fibrous, and a vestibular or endothelial. It is, however, very thin, and is in contact internally with the perilymph.

Behind the promontory and between those two windows is seen a smooth depression, the *sinus tympani*, which varies considerably in size.

It is important as marking the situation of the ampulla of the posterior semicircular canal.

The anterior wall of the tympanum is formed by the convergence of the floor and the roof of a double-barrelled canal, divided by a thin plate of bone, often incomplete—the cochlear process—which is continued into the Glaserian fissure. The upper canal, about 12 mm. in length, opens immediately in front of the fenestra vestibuli and contains the *tensor tympani* muscle; while the lower is the osseous portion of the Eustachian tube. It is interesting to note that these two apertures are

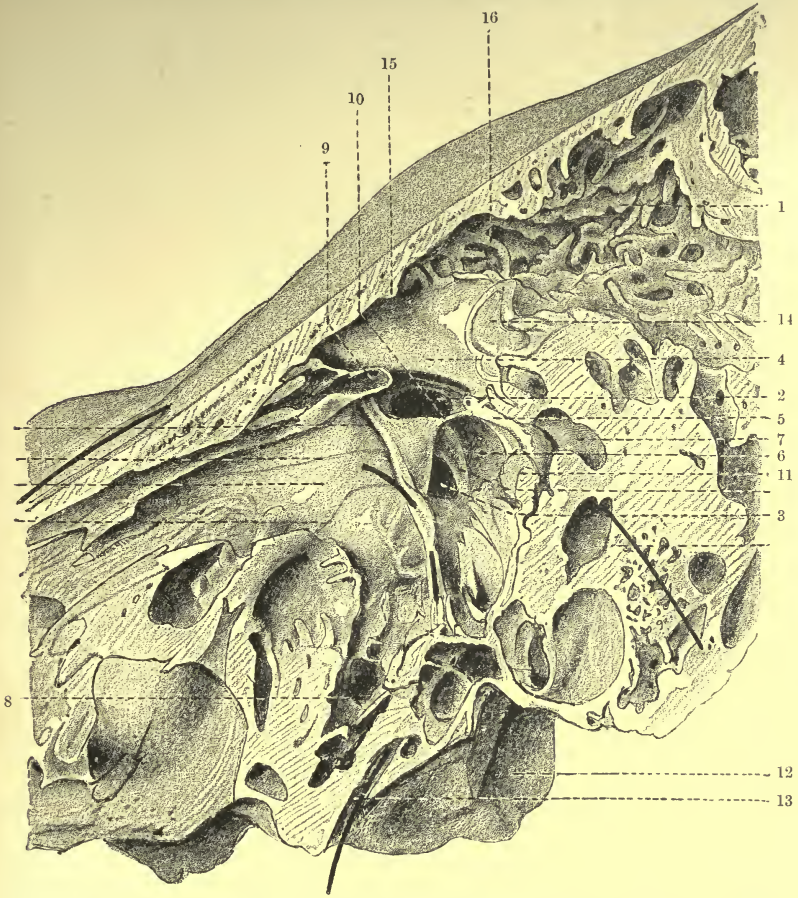

Fig. 90.—Section of right temporal bone showing the antro-tympanic cavities (magnified). 1, Antrum; 2, fenestra ovalis; 3, fenestra rotunda; 4, prominence of Fallopian aqueduct; 5, pyramid; 6, tympanic sinus; 7, posterior sinus; 8, tympanic cells; 9, canal for tensor tympani; 10, bridge uniting pyramid and promontory; 11, styloid protuberance; 12, jugular fossa; 13, bristle passed through canal for tympanic nerve; 14, prominence of external semicircular canal; 15, tympanic crest; 16, entrance to mastoid cells.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

at about the same level as the opening into the mastoid antrum, and further that the lower or *ostium tympanicum* is very large in infancy. This wall is closely related to the carotid canal, being separated from it by spongy tissue, which communicates with a venous sinus, the *sinus cavernosus.*

The Mastoid Antrum.—The mastoid antrum (so-called) is in reality a portion of the middle-ear cleft, and is not, as was formerly described, a diverticulum of the tympanic cavity.

It may be seen at a very early stage of foetal life as a small recess between the convergence posteriorly of the squamo-zygomatic and petrous elements of the temporal bone (Fig. 91). Its growth and expansion are, however, relatively much greater than that of the tympanic portion of the middle-ear cleft. About the sixth month of intra-uterine life, *i.e.* directly after the fusion of the centres of ossification of the periotic capsule, the different cavities of the middle-ear cleft are visible and their continuity well marked, while at birth the antrum is a well-defined chamber communicating with the tympanum proper by means of a narrow passage, the *aditus ad antrum.*

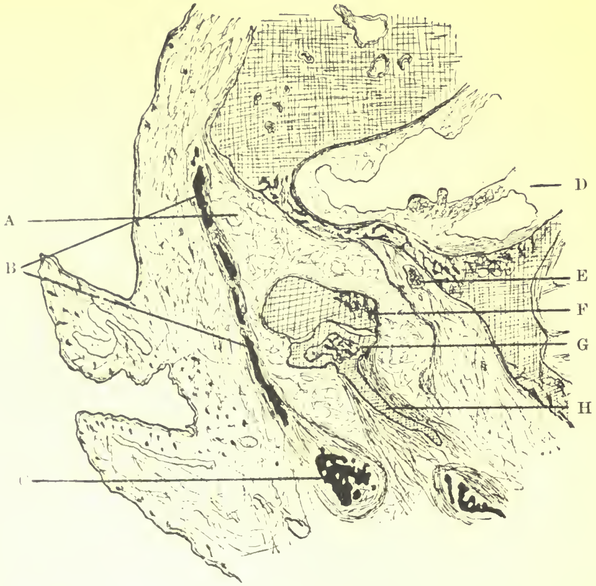

Fig. 91. Middle-ear cleft at about four months of foetal life. A, Antral recess; B, squama; C, tympanic bone; D, vestibule; E, facial nerve; F, incus; G, malleus; H, Meckel's cartilage. (From Mr. Th. Guthrie's article upon "The Development of the Mastoid," *B.M.J.*, Oct. 12, 1907.)

The mastoid cells are, however, in all probability offshoots from the antrum, and appear even before birth as small pit-like diverticula or rudimentary air-cells.

During the second or third year they are so far formed as to constitute a quite distinctive feature, while at puberty they are well developed.

It will be expedient to describe the *Eustachian tube* in its entirety. It is a canal about 35 mm. in length, having a lumen from 2 to 3 mm. in diameter. From the tympanum it is directed obliquely downwards, inwards and forwards, forming an angle of about 45° with the sagittal plane, with an inclination of about 30° downwards from the horizontal. It consists of two portions, an osseous or tympanic, which is lodged in the petrous bone, about 12 mm. long, opening into the anterior wall of the tympanum as a funnel-shaped aperture, the *ostium tympanum*. With the carotid canal on its mesial aspect, it rapidly diminishes in calibre to the *isthmus tubae*, its narrowest part being where it joins the cartilaginous section. This part consists of a triangular plate of fibro-elastic cartilage, unsymmetrically bent to from a hook, leaving an interval on its anterior and lower aspect, where the canal is completed by the *fascia salpingo-pharyngea*, by muscular fibres from the tensor palati, and by adipose tissue. It terminates in the naso-pharynx by attachments to the scaphoid fossa of the sphenoid, as a large compressed trumpet-shaped slit, the *ostium pharyngeum*, which relatively to the palate is lower in the child than in the adult. This aperture is bounded above and posteriorly by the cartilage which separates it from Rosenmüller's fossa. Below it and anteriorly is the salpingo-palatine fold, containing the tensor and levator palati muscles. The mucous membrane, lining the osseous region, is thin and inseparable from the periosteum except along

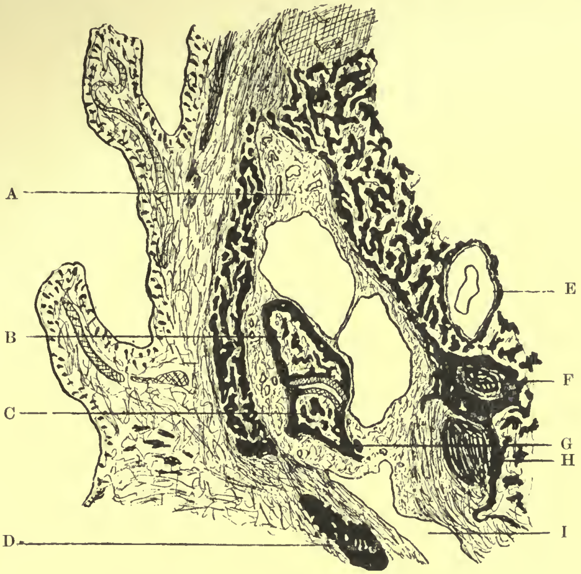

FIG. 92.—Middle-ear cleft at about 7½ months of foetal life. Absorption of the embryonic gelatinous tissue has begun. A, Antrum; B, incus; C, malleus; D, tympanic bone; E, external semicircular canal; F, facial nerve; G, chorda tympani; H, tensor tympani muscle; I, Eustachian tube. (From Mr. Th. Guthrie's article upon "The Development of the Mastoid," *B.M.J.*, Oct. 12, 1907.)

the floor where venous spaces are plentiful. It is lined by ciliated columnar epithelium throughout, while mucous glands of the acino-tubular variety are plentiful in the cartilaginous, but diminishing in number are but few in its osseous region. The mucous membrane varies considerably in its total and relative thickness, in parts exhibiting numerous folds, especially near the pharyngeal ostium, so that it must be regarded only as a potential but not a patent canal throughout its greater part.

In the neighbourhood of the *ostium pharyngeum* small islands of cartilage have been described by Moos which, co-operating with the adjacent tendons, act as sesamoid cartilages.

It is important to bear in mind that in early life the Eustachian tube is relatively wider, shorter, and more horizontal than in the adult. It is thus brought into closer intimacy with the food tract.

The *posterior* boundary of the tympanum presents from above—first, a large but variable-sized opening which leads into the mastoid antrum, the so-called accessory sinus of the tympanum. At its lower margin is a small depression for the attachment of the ligament of the incus, while just below the orifice lying behind the fenestra vestibuli is the pyramid or *eminentia papillaris*, from whose apex issues the stapedius muscle which arises from a cavity in its interior. This cavity may be traced to the cranial base as a small aperture near the stylo-mastoid foramen, while during its course it is connected with the Fallopian aqueduct. Occasionally a delicate bony filament stretches from the apex of the pyramid to the promontory. Below the pyramid, and on a level with the fossula rotunda, is often seen a sharp projection of bone, the tympanic end of the *styloid process*, which, although usually ossified before birth, often remains cartilaginous.

The *lining membrane* of the tympanic cavity is so closely blended with its bony walls as to constitute a modified periosteum. At no point, except near the ostium of the Eustachian tube, is the term "mucous membrane" correctly applicable, for here alone does it contain glands or assumes any appreciable degree of thickness.

It is thin, transparent, vascular, and not easily detachable from the bone. Although continuous with the mucous membrane of the naso-pharynx, and morphologically part of the hypoblastic tube, it has more of the histological characters of a serous than of a mucous membrane. It bears a striking resemblance to the membrane lining the nasal accessory cavities.

During foetal life the tympanic chamber is filled with vascular embryonic gelatinous tissue containing a prolongation of the epithelium of the foregut. Just before birth this tissue undergoes a rapid shrinkage and disappears, leaving strands of vascular fibrous elements covered with ciliated epithelium. Relics of this structure are seen in the various ligaments, pouches, and vascular fimbriae which remain as permanent yet variable structures.

At birth the cavity contains air and a large number of degenerating epithelial and connective tissue cells, with leucocytes, lymphocytes, and amorphous granules which rapidly disappear, leaving a relatively thick and velvet-like lining. Near the tympanic membrane and promontory, vascular thickenings or papillae remain till adolescence, while the ciliated epithelium is rapidly replaced by cubical and flattened cells, except over the region of the Eustachian ostium. In acute suppuration of the middle-ear during early infancy columnar and even ciliated epithelium may be seen in the discharge during the early stages of the disease. Such cells are never seen in the primary discharge of like affections in adults, being either spheroidal or flattened in shape.

Sections of the lining membrane taken from the region of the promontory in an adult show a single layer of flattened elliptical or spherical epithelial cells lying on a thin hyaline basement membrane. Below is a loose layer of fixed connective tissue cells (fibroblasts), mingled with white and elastic fibres, which form a supporting stroma for thin blood-vessels and lymph channels, and gradually merge into the more densely-packed fusiform cells of the periosteum. The large elongated endothelial plates which line the blood and lymph channels are very conspicuous, while "wander cells" or leucocytes mingle with the delicate fibres of the reticular tissue, attended by lymphocytes and plasma cells in inflammatory states.

Politzer describes the existence of numerous oval and pyriform bodies belonging to the connective tissue elements, which he interprets as vestiges of the embryonic gelatinous tissue. They are apparently laminated swellings of the white or gelatinous fibres covered with epithelium, and occur in the posterior portion of the tympanum, on the tympanic membrane, in the epitympanum and antrum.

With regard to glands they are certainly not numerous. The writers have searched for them very carefully, but have only found most rudimentary examples of the acino-tubular type in the immediate neighbourhood of the *ostium tympanicum* of the Eustachian tube, of whose lining membrane they represent a modified continuation. They appear as sinuous tubes with slight dilatations or acini, lined with a single layer of compressed or pyramidal cells of the mucous type. Their ducts are extremely short, and are lined with stunted "palisade" epithelium similar to that of the surface but without cilia. In this region the surface cells are distinctly ciliated, but over the rest of the cavity they are either short cubical cells or flattened spheres devoid of cilia. The antral cavity is lined by short columnar ciliated epithelium before birth, which however becomes changed to simple, short, cubical, and flattened cells in the adult. When subjected to chronic disease they are invariably flattened or squamous and several layers in thickness.

Recesses or Pouches of the Tympanum.—Viewed as a dry or purely osseous preparation the cavity of the tympanum although irregular, appears as a complete or uninterrupted chamber, yet in the fresh state it is divided up into a number of anfractuous spaces by the ossicles, their ligaments, and folds of the lining membrane. These folds and the irregularities of surface which they cover produce pouch-like portions of the general cavity, which may be separately and individually the seat of morbid lesions. Although for the most part of constant occurrence they present considerable variation in size and shape, and may be looked upon as necessary and useful relics of the original embryonic tissue which filled the tympanum.

One of the most interesting of these pouches is found between the head of the malleus and incus on the one hand, and the external tympanic wall on the other. It is formed by the lining membrane as it covers their ligaments, and is divided into a superior space, which is bounded in front by the grooveless part of the *margo tympanicus*, behind by the malleal head, and below by a fold which extends from the edge of the tympanic ring to the neck of the malleus uniting its anterior and external ligaments. Immediately below it is the inferior or Prussak's space which is bounded externally by the *membrana flaccida*, below by the *processus brevis*, and behind by the neck of the malleus and an opening into the main tympanic cavity. This pouch is one of the most constant, but may vary very considerably in size, shape, and freedom of communication (Fig. 93).

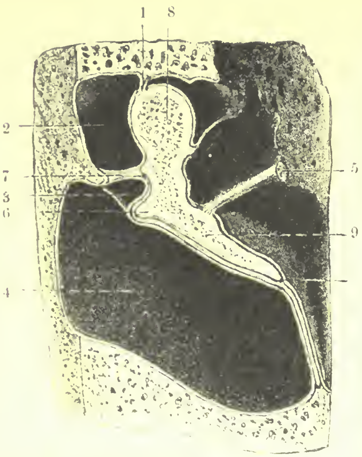

FIG. 93.—Section through malleus and tympanic membrane *in situ*. 1, Superior ligament of malleus; 2, upper pouch; 3, Prussak's space; 4, external meatus; 5, tensor tympani; 6, processus brevis; 7, external ligament of malleus; 8, head of malleus; 9, manubrium mallei.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

The anterior and posterior pouches of Tröltsch are formed by a fold which passes down from the roof towards the inner or mesial aspect of the neck of the malleus, including the chorda tympani. From it two pouches extend, one in front of and the other posterior to the malleal handle, but bounded externally by the tympanic membrane.

The **ossicles** are situated in the upper part of the tympanum, and form an interrupted angular connection between the tympanic membrane and the fenestra vestibuli. They are kept in position by ligaments and folds of the lining membrane, and are controlled by muscles. They are almost as large at birth as in middle age.

The *malleus*, which weighs about 20 m.grm. and is about 18 mm. in length, presents for examination the following features (Fig. 94).

The head or *capitulum*, which is situated entirely in the epitympanum, nearly touching its outer wall, has a smooth, free convex surface and a concave articular surface marked by facets bounded below by a ridge or spur, which rests on the lower facet of the incus. The neck or constriction is followed by a slight thickening from which spring the processes. The *processus gracilis*, which projects from the neck (a mere spiculum of bone in the adult), is continued as a fibrous ligament and is attached to the sides of the Glaserian fissure.

The *processus brevis* is situated on the manubrium below the neck, and points externally to the tympanic membrane with which it is closely united. It is often cartilaginous even in adults.

The *manubrium* forms an obtuse angle with the head, and rests on the middle layer of the tympanic membrane, to which it is closely united by periosteum and a layer of cartilage. It tapers gradually to a flattened point and is slightly twisted, having an inclination slightly forwards and inwards.

The *incus* is situated above the level of the tympanic ring, and consists of a body and two processes. The body has in front a deep, sellaform, facetted, articular surface, whose lower margin is excavated and ridged for contact with the malleal spur (Fig. 94).

Its *processus brevis* is tipped with cartilage and projects backwards, being attached to the margins of the antral entrance.

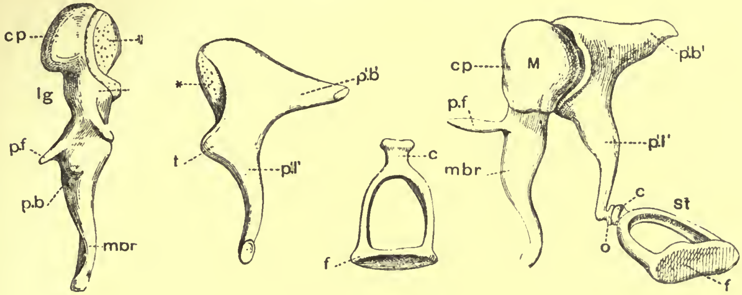

FIG. 94.—The ossicles.

The *processus longus* passes downwards and inwards, parallel to and behind the malleal handle, its extremity being sharply bent inwards, and forms the lenticular process or *os orbiculare*, which articulates with the stapes. This orbicular bone is only separate in the foetal state and is cartilaginous during the greater part of life.

The *stapes* placed horizontally consists of a head, neck, two arms, and a footplate (Fig. 95).

The head, which is directed outwards, is slightly concave and covered with hyaline cartilage, which articulates with the *os orbiculare.* The neck is slightly constricted and receives the insertion of the stapedius muscle. From it pass two crura, which terminate in the footplate, forming an arch across which a thin membrane extends in the recent state. The anterior arm is slightly shorter and straighter than the posterior. The base or footplate is loosely attached to the oval window, and is sometimes covered on its vestibular aspect with hyaline cartilage.

Articulations.—The ossicles are united by joints similar in principle to those of the skeleton, the friction surfaces being covered with a thin layer of hyaline cartilage and enclosed in a loose synovial membrane. The malleo-incudal joint contains a fibro-cartilaginous meniscus somewhat wedge-shaped. The incudo-stapedial joint is much closer and its synovial character is disputed, although Rudinger describes it so, and as also possessing an interarticular fibro-cartilage.

The attachment of the stapes to the oval window possesses both anatomical and pathological interest.

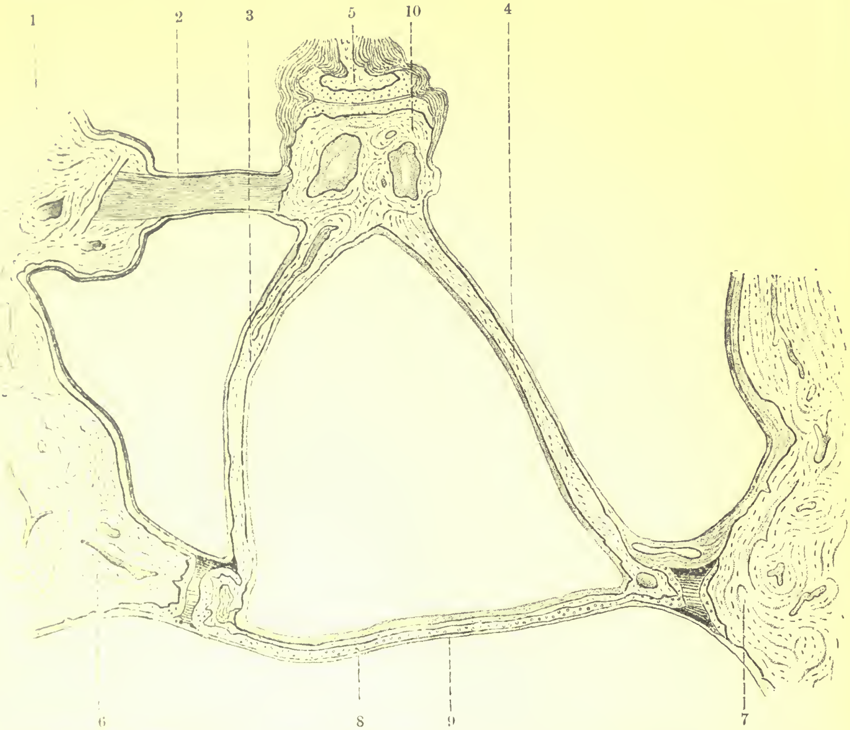

FIG. 95. The stapes *in situ*. 1, Pyramid; 2, stapedius; 3, posterior crus of stapes; 4, anterior crus of stapes; 5, lenticular process of incus; 6, posterior boundary of fenestra ovalis; 7, anterior boundary of fenestra ovalis; 8, footplate of stapes; 9, lining of vestibule; 10, head of stapes. (From Quain's *Anatomy*, vol. iii. pt. iii.)

The vestibular window is approached from the tympanum by a shallow fossa or funnel into which the stapes loosely fits. Across the vestibular aspect is continued the endothelial and connective tissue lining of the labyrinth on which the cartilage-covered footplate rests. The adjacent margins of the oval window are also covered with cartilage, from whose perichondrium fibres pass to the edge of the footplate. The tympanic aspect of these structures is covered by the lining of that cavity.

Ligaments.—The joints are not only strengthened by ligamentous fibres, but the bones themselves are supplied by "check" fibres which pass to them from the tympanic wall enveloped by reflections of the lining membrane.

The malleus possesses three distinct sets:

1. The *Anterior* is a strong, broad band of fibres which, starting from the *processus gracilis* and the anterior surface above it, passes to the Glaserian fissure and to the anterior spine of the tympanic ring in front of the notch of Rivini. That portion joining the Glaserian fissure was at one time described as the *laxator tympani* muscle.

2. The *External* ligament is a fan-shaped structure which, passing from the notch of Rivini, converges to the neck of the malleus and forms part of the upper wall of Prussak's space.

3. The *Superior* ligament is a small, short bundle which connects the capitulum with the tympanic roof and checks the outward movements of the manubrium and tympanic membrane.

There is an accessory anterior ligament in the shape of fibres passing along the sheath of the tensor tympani from the cochleariform process to the neck of the malleus, strengthened by fibres from the anterior tympanic wall.

The incus is attached to the margins of the antral entrance on the posterior tympanic wall by fibres spreading outwards and inwards from its short process which is tipped with fibro-cartilage.

Muscles.—Two are recognised.

The *Tensor Tympani* consists of a sarcous portion, half an inch in length, which arises from the cartilaginous end of the Eustachian tube, the adjacent surface of the sphenoid bone, and from the wall of its own canal. Becoming tendinous, it issues from the trochlear end of its canal in front of the fenestra vestibuli, and turning at a right angle over the edge of the cochlear process enclosed in a strong fibrous sheath, passes outwards to be inserted into the inner aspect of the handle of the malleus near its root. It derives its motor supply from the fifth nerve through the otic ganglion.

The *Stapedius*, whose sarcous portion is hidden in and arises from the interior of the pyramid, issues as a short tendon from its apex. Covered with a fibrous sheath, it is inserted into the posterior aspect of the neck of the stapes close to its articulation with the lenticular process.

Bone is constantly found in this tendon in most mammals, but only occasionally in man.

Arteries.—The arteries of the tympanum are numerous although small, and are derived from the internal and external carotid.

The Tympanic branch of the internal maxillary entering by the Glaserian fissure, supplies the anterior part of the tympanum, while the posterior part, including the antrum and mastoid cells, is supplied by the stylo-mastoid branch of the posterior auricular artery, which enters by the Fallopian canal. These freely anastomose and form a special vascular circle round the periphery of the tympanic membrane.

From the Middle Meningeal artery a small branch, the petrosal or Fallopian, enters by the *hiatus Fallopii*, and a tympanic branch which runs in the canal for the tensor tympani; while the internal carotid furnishes some small branches which pierce its own canal.

The stylo-mastoid supplies a twig to the vestibule through the *fenestra cochleae*, while other parts of the bony labyrinth receive blood from its tympanic branch, but no anastomosis has been demonstrated with the arteries of the membranous labyrinth which are derived from the basilar.

The ascending pharyngeal artery sends a small branch, the tympanic, which accompanies Jacobson's nerve in its course through the tympanic canaliculus; it traverses the *corpus tympanicus*, and is distributed to the region of the promontory and vestibular window.

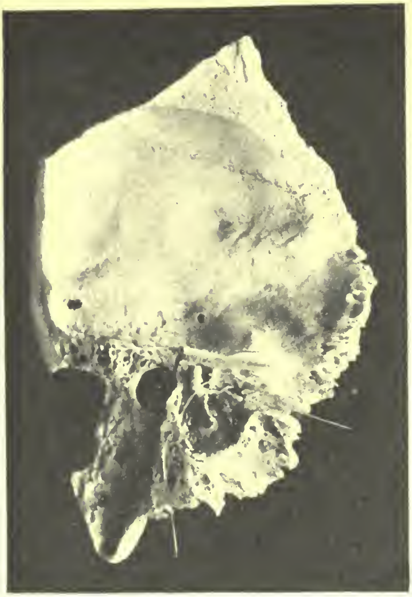

Fig. 96.—Cavity of the middle ear, viewed from within, showing the course of the chorda tympani nerve (represented by a wire).

It is important to note the very close relationship between the lining membrane of the tympanum and its osseous walls through the arterial distribution. The arteries of the lining membrane pass so freely through the periosteum into the subjacent bone that any inflammatory process of the lining membrane necessarily involves great risk to the osseous wall.

According to Prussak, the arterial supply of the tympanum breaks up into a very rich meshwork of vessels which are individually very large, and pass directly into the veins without the intervention of capillaries.

Sections in all regions of the lining membrane show a plentiful distribution of arterioles, the visceral muscle fibres in their walls being exceptionally well marked.

The Eustachian tube at its tympanic end is chiefly supplied by the tympanic branch of the middle meningeal artery, while its pharyngeal portion by the ascending pharyngeal from the external carotid, and the vidian from the internal maxillary.

The venous radicles are extremely tortuous, and exhibit a tendency to cavernous distension.

Venous blood is collected from the tympanum into the sigmoid and the superior petrosal sinuses, as also into the temporo-maxillary and middle meningeal veins, while the lymphatics, which form somewhat large spaces in the gaps between the interlacing bundles of fibrous tissue, and in the well-marked channels surrounding the arteries and nerves in their canals, pass to the deep jugular and carotid chains. There are, however, important connections with the prevertebral glands which may become the seat of retro-pharyngeal abscess in middle-ear suppuration, and also with the ante-tragal and retro-auricular glands.

The *nerves* in connection with the tympanic cavity are either functionally related to the part or merely connected with it anatomically, and are therefore only of surgical interest. Its lining membrane is supplied by filaments from the tympanic plexus which rests on the promontory. This plexus is formed by the following nerves:—

1. Jacobson's nerve, which starts from the ganglion of the glossopharyngeal nerve, ascends through the canaliculus on the jugular ridge, where it passes through its *corpus tympanicus* or pseudo-ganglion and enters the tympanic cavity just below the promontory.

2. The small deep petrosal, which is a twig from the carotid plexus and joins Jacobson's nerve after piercing the carotid canal by the *canaliculus petrosus.*

3. The small superficial petrosal nerve which joins the otic ganglion, passing beneath the tensor tympani canal.

4. Finally, there is a branch which joins the great superficial petrosal nerve and runs in a canal opening in front of the *fenestra vestibuli.*

Thus the cavity receives its sensory supply from the fifth and ninth nerves; its vaso-motor through the carotid plexus.

The tensor tympani derives its motor supply from the fifth nerve through the otic ganglion by its internal pterygoid branch; the stapedius from the seventh nerve.

The chorda tympani is simply a traveller so far as the tympanum is concerned. Arising from the facial near the lower end of the aqueduct, it enters the tympanum by the *iter chordae posterius* just below the pyramid, crosses the chamber near its outer wall over the posterior half of the tympanic membrane, the malleal handle, and gracilis process in succession, and finally leaves by the *iter chordae anterius* close to the Glaserian fissure (Fig. 96). In its journey the lining membrane of the tympanum closely invests it.

Communications of the Antro-Tympanic Cavity.—Before closing the anatomy of this chamber it will be expedient to briefly review its numerous and complex connections, connections which play such an important part in its morbid lesions, for experience teaches that any one of these channels may be selected by infections as passages to or from the cavity. While some of them are more permeable during infancy than in adult life, every cleft or aperture constitutes a potential channel for infection at any period.

With the pharynx and body surface:—
Eustachian tube.
External auditory meatus.

With the cranial cavity:—
The sheath of the seventh nerve.
The sheath of the eighth nerve through the labyrinth.

The sheath of the vestibular artery through the labyrinth.
Ductus endolymphaticus by the aqueductus vestibuli.
Hiatus subarcuatus.
Veins to superior and inferior petrosal sinuses.
Petro-squamosal suture.
Hiatus Fallopii and adjacent canal for lesser petrosal nerve.

With the adjacent deep structures :—

Aqueductus cochleae and ductus perilymphaticus (through the labyrinth).
Canal for Jacobson's nerve (canaliculus tympani).
Canal for tensor tympani.
Canal of Huguier.

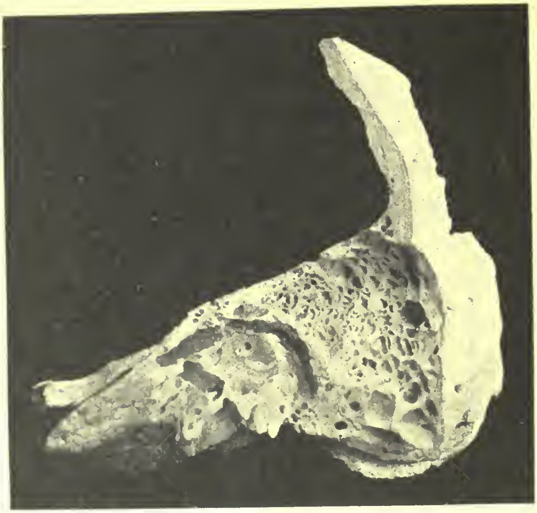

Fig. 97.—Temporal bone showing diploetic structure of mastoid process, the course of the Fallopian aqueduct, and the external semicircular canal.

Canal for stapedius muscle.
Temporo-maxillary vein.
Glaserian fissure.
Carotid canal (carotico-tympanic tubules).

Development of the Petro-Mastoid.—At a very early period the otic vesicle or rudimentary labyrinth is embedded in the basi-cranial mesoblast, which becomes chondrified by the eighth week of foetal life and constitutes the periotic capsule. Its ossification begins about the fifteenth week in four distinct centres. One of these, the opisthotic, lies posteriorly to the external semicircular canal, and from it the outer end of the petrous and the mastoid elements are derived. It is fully ossified, and fixed to the other centres about the fifth month.

The osseous centre for the squamous element is, however, deposited in membrane, and appears about the seventh week. This squamous bone overlaps the mastoid, but between them there remains a space, the antrum, a continuation of the rudimentary tympanic chamber. At birth it is relatively large, and is the only part of the bone which is pneumatic. It measures about 10 by 6 mm. Compared with the tympanic at this period the mastoid is relatively a small structure, and does not become a distinct tubercle until the end of the first year.

On histological examination the squamal boundary of the antrum is found to be composed of a thin layer of compact bone beneath the periosteum, with a few very fine cells on its antral aspect, while the mastoid is diploetic throughout except a thin layer of compact tissue beneath the periosteum, a similar one bounding the antrum.

Such is the condition at birth, and the antrum (somewhat misleadingly called the mastoid antrum) may be considered as a space derived from part of the original antro-tympanic chamber excavated in the opisthotic element, and covered externally by a membrane bone, the squama.

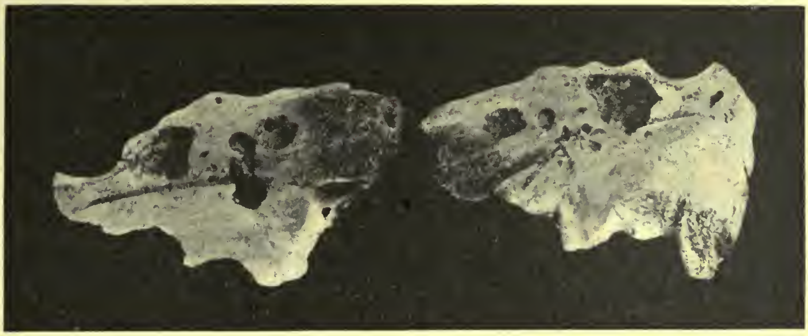

FIG. 98.—"Infantile" type of temporal bone from a patient aet. 24. Case of acute suppurative otitis media. Death from suppurative meningitis.

As ossification progresses the squama also becomes but slightly diploetic and much thicker, while the mastoid becomes more prominent as the tympanic ring seems to recede, taking with it the tympanic membrane. But during infancy and childhood the squamous element may not undergo diploetic changes, but develops as a dense compact bone all through, with the exception of the small cells on its antral aspect, a condition which it may retain permanently. Meanwhile the mastoid proper remains diploetic throughout except its antral boundary, which increases in density. Pneumatic cells are not found.

Such is the condition which has been termed the "*infantile type*" (Fig. 98). It is simply a more or less exaggerated state which simulates the condition found in early life. In it the antrum is usually found to be small and high, while the adjacent cell spaces are very shallow. Cheatle[1] has further shown that the mastoid may also become dense, especially that portion bounding the antrum, and that it is intimately associated with other variations from the normal which it seems to favour, viz. a forward position of the lateral sinus, and a thinning of the posterior wall which separates the antrum from the sinus and cerebellum.

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[1] *Trans. Otol. Soc.* viii.

The essential feature is, therefore, an exaggerated condensation of the bone with diminished osteo-porotic changes. It represents an unbalanced ossification, which is more marked in the squamous than in the petromastoid element.

The existence of such an anatomical condition is of no small interest clinically, since it may not only help to mask the external signs of antral suppuration, but by its resistance favours deep extension of infection, while to the surgeon it adds operative difficulties. It is not surprising, therefore, that its interpretation is the subject of considerable diversity of opinion. That it is merely the persistence and exaggeration of an early phase of development is maintained by many; that it is the result of morbid influences receives equal support.

Too much emphasis must not be placed on the assumption that since the type is well demonstrated in skulls which present no evidence whatever of aural disease, that morbid influences are not responsible for similar changes which are revealed by operation.

That osteo-sclerosis does occur in the mastoid in many cases of antrotympanic disease, there is no doubt whatever; but whether the peculiar condensation and thickening of the squama is of similar origin requires further investigation.

Available anatomical evidence supports the view that while longstanding disease may be and is responsible for eburnation in the petromastoid, in the case of the squama other and various influences may be at work.

The growth and structure of all bones are considerably modified by the functional activity of the muscles attached to them. This may be specially so in the case of the squama and mastoid, owing to the attachment of the powerful masticatory and neck muscles.

Exaggerated eburnation and restricted porotic changes in bone development occur in other parts of the skeleton as the result of nutritive influences, from which the temporal bone is not exempt.

CHAPTER XII

INFLAMMATORY AFFECTIONS OF THE MEMBRANA TYMPANI

Acute Myringitis.—Acute inflammation of the dermic layer of the membrana tympani may occur as the result of direct exposure to cold draughts, the entrance into the meatus of sea-water while bathing, the instillation of irritating applications, the introduction of foreign bodies into the ear, or the extension of a previously existing diffuse otitis externa. It is usually unilateral, and may affect the whole surface of the membrane or remain localised to a particular area.

Symptoms.—The main symptoms are sudden onset of pain, fulness in the ear, tinnitus, and a moderate degree of deafness. The amount of pain varies, being at times, especially in children, very severe. As a rule, it is complained of as being gnawing or lancinating, and situated deeply in the meatus; at other times it radiates over the corresponding side of the head. It is aggravated during the mastication of food and by loud noises. The deeper the inflammatory process extends the greater the pain.

The degree of deafness is never so severe as in cases of acute otitis media: in fact the comparative absence of deafness is one of the most important means of differentiating an acute myringitis from an acute otitis media.

In children a certain amount of fever, combined with restlessness and irritability, may be present.

The objective indications of the disease consist in congestion and swelling of the outer layer of the membrana tympani, obliteration of the normal landmarks, and the occasional presence of haemorrhagic bullae upon its surface. In the early stages of the affection the blood-vessels running in front of and behind the handle of the malleus become congested and visible, while later on the whole membrane assumes a dull-red, cherry-like appearance. Hyperaemia and swelling may also extend to adjacent parts of the auditory meatus. In severe cases small bullae form upon the surface of the membrane, which, after a short existence, rupture and discharge their blood-stained, serous, or purulent contents. Within from seven to ten days desquamation of the outer layer of the membrane follows. In many cases the whole of the dermic layer becomes exfoliated, leaving a raw, red, and irritable surface behind. The amount of discharge varies with the intensity of the inflammation and the size of the bullae.

In favourable cases the discharge and exfoliation of epidermal cells rapidly cease, and a return to the normal takes place, or the disease assumes a chronic phase with at times the production of small oedematous buds of granulation tissue.

In exceptional cases perforation of the membrane and infection of the middle ear result.

Diagnosis.—The diagnosis of an acute myringitis rests mainly upon the fact that in myringitis the amount of pain and the degree of deafness are not so pronounced as in an acute otitis media, the objective appearances of the two diseases being practically similar. When discharge is present, it is of the utmost importance to determine whether this comes from ruptured bullae or from the cavity of the middle ear through a perforated membrana tympani. This can only be determined by a careful otoscopic examination, by the employment of Siegle's speculum, inflation of the middle ear by Politzerisation, or by the passage of the Eustachian catheter. If a perforation, however minute, be present, the passage of air through it, as the result of inflation, will be heard by means of the auscultation tube.

Deep-seated pain in the ear of a reflex character from the presence of carious teeth, an ulcerated throat, tuberculosis or carcinoma of the larynx, may simulate the pain produced by an acute or chronic myringitis. The absence, however, of any congestion of the membrane and the non-obliteration of the landmarks serve as good differential diagnostic indications.

The discharge consists at first of nucleated squames, but these are rapidly reinforced by leucocytes, poly- and mono-nuclear, mixed with bacteria, many in number but few in variety. Staphylococci and Gram — diplococci most frequently occur, but gonococci are not rare, especially in infants. The *bacillus coli communis* is by no means uncommon, and is often accompanied by the *bacillus proteus vulgaris.*

Treatment.—In the early stages of the affection, rest and quiet are indicated. The application of two or more leeches in front of the tragus or the employment of the artificial leech, by causing rapid depletion, affords speedy relief. Dry heat, *e.g.* a rubber water-bottle or a sand or bran-bag applied over the auricle, is also beneficial. The instillation of a few drops of a 5 per cent solution of glycerine of carbolic acid, or aluminium or lead acetate, serve to relieve pain and to diminish inflammation.

Should the bullae not rupture spontaneously, as is usual, they should be incised with a sharp paracentesis knife, great care being taken to avoid opening up the cavity of the middle ear for fear of its subsequent infection. The persistence of a discharge calls for syringing with sterilised water or a mild antiseptic lotion, and the subsequent insufflation, after careful drying of the meatus, of boric acid, boric acid and oxide of zinc in equal parts, or dermatol powder. Any existing deafness is, as a rule, speedily relieved by inflation.

Chronic Myringitis.—Chronic myringitis is at times met with as a sequel of acute myringitis, or may result from the constant irritation of a foreign body, plug of cerumen, external cholesteatoma, or as a sequel to an otitis externa which has run its course. It is accompanied by a slightly purulent and frequently foetid discharge, by a feeling of fulness and itching in the ear, and at times by slight deafness.

After syringing, the membrane appears of a dirty wash-leather colour and studded with minute excoriations or flabby granulations.

Treatment.—The meatus should be syringed with a weak alkaline antiseptic lotion, painted with a 5 to 10 per cent solution of nitrate of silver, and dusted with dermatol or boric acid powder.

Attention should be directed to the patient's general health and tonics given.

CHAPTER XIII

TRAUMATIC LESIONS OF THE MEMBRANA TYMPANI

Traumatic Rupture of the Membrana Tympani.—Rupture of the membrana tympani may be produced by direct or indirect violence.

The principal causes of direct injury are the introduction into the meatus, accidentally or on purpose, of foreign bodies, such as pins, hair-pins, pencils, pens, toothpicks, etc., unskilful efforts made to extract foreign bodies, the clumsy introduction of aural instruments without sufficient illumination and without a proper knowledge of the size, shape, and curvature of the canal, and the injudicious use of the Eustachian bougie, especially in those cases where the membrana tympani is greatly retracted or bound down by adhesions to the inner wall of the middle ear. Workmen, *e.g.* stone-cutters, metal-finishers, at times receive direct injuries to the membrane from flying particles of stone or metal. Surf bathers and divers are also prone to rupture of the membrane from the forcible impact of water under pressure.

Rupture of the membrane from direct violence may be accompanied by fracture of the manubrium mallei and dislocation of the ossicles.

Indirect injuries, such as blows upon the ear, especially with the open hand, or condensation of air within the meatus from the sudden and unexpected discharge of fire-arms or heavy artillery, explosion of shells, gas explosions, diving, or violent syringing of the ear, are prone to produce rupture with or without simultaneous concussion of the labyrinth.

A rupture of the membrane is more likely to take place when the concussion, from whatever cause, is unexpected, and when the membrane has previously been weakened by atrophy, calcareous degeneration, post-suppurative cicatrisation or chronic Eustachian obstruction. Caisson workers are also subject to rupture of the membrane, especially when the pressure of air within the diving-bell is not very gradually and slowly increased and also during too rapid decompression. Another cause of indirect rupture of the membrane is fracture of the base of the skull extending through the petrous and tympanic portions of the temporal bone. When the line of fracture runs along its anterior surface, by the side of the labyrinth, and through the middle ear, there is as a rule extensive laceration of the membrane but no escape of cerebro-spinal fluid; on the other hand, when it involves the roof of the tympanum and auditory meatus there is often a free discharge of cerebro-spinal fluid lasting for several days.

The too forcible inflation of air into the tympanum by Politzer's air-douche or by means of the Eustachian catheter, excessive rarefaction of air within the auditory meatus with Siegle's speculum, Delstanche's rarefacteur, or Sondermann's suction apparatus, and too energetic kissing over the region of the auditory meatus are also occasional causes of rupture of the membrane, especially if it be already weakened by previous disease.

Stenosed conditions of the Eustachian tube and nasal obstruction greatly favour rupture owing to the difficulty with which the suddenly condensed air within the middle ear is able to escape. A timely rupture of the membrane, the force being expended in causing a solution of its continuity, frequently, however, saves the internal ear from damage.

The normal membrane has been shown by Gruber[1] to possess great powers of resistance, and to be able to withstand a gradually increased pressure of from sixty to seventy pounds. The fact that the blow, fall, or other injury is suddenly inflicted, before the membrane has time to accommodate itself, as it were, has, in all probability, a good deal to do with the causation of its rupture, as has also its occasional rigidity.

Symptoms.—At the moment of rupture a loud report is heard by the patient, followed immediately by severe pain, deafness, sickness, and dizziness, and at times by an actual attack of syncope. Tinnitus of a loud, rushing, and persistent character is also common, especially when a co-existing labyrinthine lesion is present.

The degree of deafness which supervenes is frequently remarkably slight, especially in those cases of rupture due to direct injury, and unaccompanied by any pathological change in the internal ear. Such symptoms may last for weeks, or even months, before passing off. On the other hand, involvement of the labyrinth frequently leads to high grades of deafness, usually of a permanent nature.

Ruptures due to direct violence are more prone to lead to permanent defects of hearing, partly from the fact that suppurative inflammation is more likely to take place, and also because involvement of the labyrinth is more common. In addition, even after suppuration has been arrested, a permanent perforation may remain, whose margins may become adherent to the inner tympanic wall.

Objective Appearances.—The appearances presented by a ruptured membrana tympani are characteristic if seen shortly after the receipt of the injury. In cases due to direct violence the rupture is usually situated in its posterior segment, whilst in those due to indirect causes it is situated antero-inferiorly between the handle of the malleus and the *annulus tendinosus* (Fig. 99).

A rupture due to indirect violence is at first somewhat linear, but rapidly assumes an elongated, oval, and, finally, circular shape, due to retraction of the radial fibres of the membrane.

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[1] *Lehrbuch der Ohrenheilkunde*, p. 310.

Its sharply defined edges are found covered by a thin layer of extravasated blood or accentuated by punctiform haemorrhages, whilst in exceptional cases they appear irregular, jagged, and incurved.

Rupture of the membrane is frequently accompanied by severe haemorrhage lasting for days, and followed at times by a serous discharge, which tends to become infected and purulent.

When there is co-existing basal fracture, profuse, and at times fatal bleeding takes place from a wounded lateral sinus or middle meningeal artery, the blood at times pouring freely from the nose and throat. Haemorrhage from the nose and throat does not, however, necessarily mean the existence of a basal fracture, as blood may readily flow into the naso-pharynx *per tubam* in the case of a severely lacerated middle ear.

Ruptures of the membrane due to direct violence present appearances which vary with the nature, shape, and size of the foreign body producing them. There may be a mere pin-point perforation or circular opening, or an irregular and jagged defect of varying dimensions. At times the rupture can only be recognised by a blood-stain or as the result of gentle inflation.

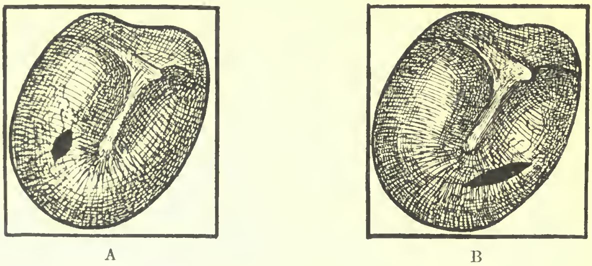

Fig. 99.—Rupture of the membrana tympani. A, Rupture by direct violence. B, Rupture by indirect violence.

In all cases of injury to the membrane it is essential to make at the time of examination detailed notes of objective appearances and subjective symptoms, as an action for damages may subsequently arise.

Treatment.—In cases due to indirect violence, the less the ear is interfered with the more rapid the process of repair and the less likely the advent of suppuration. Syringing and the use of lotions should be entirely discarded. The external meatus should be closed by a pledget of antiseptic wool or lightly packed with a strip of sterile gauze, whilst quiet and physiological rest to the implicated organ should be enjoined. When rupture is due to direct violence it is permissible to endeavour to disinfect the walls of the meatus and outer surface of the membrana tympani by the local application of hydrogen peroxide, or perchloride of mercury solution, applied with a cotton-tipped probe, or to cover the rupture with a thin pellicle of iodoform in flexile collodion after bleeding has ceased, and to lightly insufflate finely powdered boracic acid, followed by the insertion of a strand of sterilised gauze.

In cases complicated by suppuration, treatment should be carried out upon the principles recommended for the treatment of suppurative middle-ear disease.

To relieve tinnitus and to stimulate the auditory nerve in cases accompanied by labyrinthine concussion, the daily employment of the continuous current is useful. If not interfered with the torn edges of the ruptured membrane heal kindly, as a rule. The process of repair may be seen to start as a slight opacity in its inner layer, followed later on by epidermisation from its outer covering, whilst occasionally all three layers may be seen to simultaneously assist in producing cicatrisation. In cases where suppuration has taken place, the edges of the rupture may become epidermised and refuse to heal. On the other hand, the process of repair is often so complete as to render it extremely difficult after the lapse of a few weeks to say whether an injury had taken place or not.

Sportsmen and artillerymen should be warned to plug the ear with a pledget of wool, or to keep a toothpick or piece of hard rubber between the teeth, in order to as far as possible equalise the pressure upon the two sides of the membrane. The practice of boxing the ears should be absolutely interdicted, many traumatic (indirect) ruptures being due to this cause.

Prognosis.—In cases where rupture has occurred as the outcome of indirect violence the prognosis is good provided that there is no concomitant injury to the labyrinth, and that the tympanum has previously been healthy.

When, on the other hand, the injury is due to direct violence, suppuration is by no means infrequent. Hence the prognosis must depend to a large extent upon the severity of the inflammatory process, its duration, and its tendency to involve the accessory cavities of the middle ear and labyrinth. Provided that no suppuration results, and that the tuning-fork tests show absence of implication of the internal ear, the prognosis is good. Traumatic lesions of the labyrinth are rarely entirely recovered from, hence their existence invariably renders the prognosis less favourable.

Ruptures of the membrane are of great importance from a medico-legal point of view. It is necessary, therefore, to consider in detail those objective appearances due to traumatic rupture, in contradistinction to those due to disease.

It is only, however, within the first few days of the receipt of the injury that local appearances are so sufficiently distinctive as to be pathognomonic. Later on the various objective indications become so similar to those produced by disease as to render accurate differentiation impossible.

Traumatic perforations as the result of indirect violence occur, as a rule, in the antero-inferior segment of the membrane, and usually midway between the handle of the malleus and the *annulus tendinosus*, rarely extending to its periphery. More than one perforation is extremely uncommon. As a rule, the shape of the rupture is circular with sharply defined edges; at times oval, with its long axis running parallel to the radial fibres of the membrane. It is unusual to find lacerated irregular edges, although such an appearance is not unknown.

In the majority of cases of traumatic rupture the Eustachian tube is healthy and its lumen patent. Hence the ease with which the Valsalvan experiment can be performed, and the peculiar, deep, toneless sound produced as air is driven outwards through the middle ear. In rupture due to pathological causes the almost invariable partial stenosis of the tube causes the emitted sound to be high-pitched, shrill, or whistling, whilst inflation is performed with much greater difficulty. Traumatic perforations heal rapidly, as a rule, suppuration rarely taking place. Should suppuration have, however, supervened by the time of the first examination, it is not possible to differentiate the case from one of primary disease.

A further important point arises as to whether the injury inflicted upon the ear is likely to be followed by permanent impairment or actual loss of hearing.

When rapid cicatrisation of the rupture takes place with restoration of hearing, the injury is to be regarded as slight; on the other hand, when suppuration ensues, attended by the formation of granulation tissue, intra-tympanic adhesions, or involvement of the accessory spaces of the middle ear, and followed by persistent perforation and labyrinthine involvement, the injury is to be regarded as serious.

An accurate diagnosis of labyrinthine involvement is by no means always easy, and the greatest precautions should be taken against simulation (p. 512). All ordinary tests for the diagnosis of internal ear disease should be carefully and repeatedly gone over, whilst it is also advisable to insist upon more than one examination.

In those cases when the injury, real or alleged, has left the membrane intact, but has produced severe concussion of the auditory nerve, the difficulties of forming an accurate opinion are intensified from the fact that it is at times almost impossible to exclude the existence of previous tympanic or labyrinthine disease. Should the patient be seen shortly after the alleged assault, and found to possess a markedly retracted, cicatrised, or calcareous membrane, presumptive evidence is in favour of previous disease. The existence of previous disease, however, if an assault can be proved, adds to the gravity of the case, as recovery is less likely to take place, whilst on the other hand it does not negative the fact that an assault may have been committed.

CHAPTER XIV

OTITIS MEDIA CATARRHALIS

Otitis Media Catarrhalis (*Sero-mucous Middle-Ear Catarrh, Exudative Catarrh*).—Catarrhal inflammation of the mucosa lining the middle-ear tract may run an acute or chronic course. It is characterised by a varying degree of hyperaemia and swelling of the mucosa, and by the exudation of a clear mucous fluid into the cavity of the tympanum. It may run its course without any marked inflammatory symptoms, and may subside spontaneously without damage to the contents of the middle ear, or it may be followed by the formation of localised thickenings and opacities of the mucosa, or cicatricial adhesions which interfere permanently with the movements of the membrana tympani and ossicular chain.

Aetiology.—The causes of catarrhal otitis media are the extension of catarrhal inflammation from the mucosa lining the naso-pharynx, adenoid vegetations, influenza, the exanthemata, diphtheria, Bright's disease, syphilis, bronchitis, pneumonia catarrhal or lobar, and oral infection often accompanying muscular paresis following diphtheria.

Passive exudation (transudation) of serous fluid into the tympanum takes place in certain cases of post-diphtheritic paralysis of the soft palate, in cases of facial paralysis, as the result of the pressure of new growths upon the orifice of the Eustachian tube, *e.g.* sarcoma or carcinoma of the lateral naso-pharyngeal wall, and as the outcome of chronic stenosis of the Eustachian tube, the result of swelling and oedema of its mucosa. In such cases the exuded fluid is sterile; whereas in many of the cases due to inflammatory changes in the mucosa it contains bacteria. Although, as a general rule, the lining of the middle-ear tract is equally affected throughout its entire length, cases occur, however, in which the inflammatory process is localised to the neighbourhood of the *ostium tubae*, where a thick, glairy, mucous secretion may be seen to exude, and objective indications and subjective symptoms show that the tympanic cavity is not affected. This latter condition occurs more frequently in adults; in children the relative straightness, shortness, and width of the tube conduces to implication of its whole length.

Pathology.—This disease is not only intimately associated with catarrh of the nose and pharynx, but its pathology is practically the same, being marked by hyperaemia and swelling of the lining membrane, followed by the appearance of a fluid of varying character according to the nature and intensity of the infection.

Normally, the naso-pharynx is perfectly sterile; but during the course of an acute or chronic "cold" many and various bacteria are found in it, especially a Gram – diplococcus, the *diplococcus catarrhalis*, the *bacillus septus*, and the *bacillus capsulatus mucosus.*

These micro-organisms are not only present in a large variety of middle-ear troubles, but are also, doubtless, responsible in no small degree for most of the minor forms of inflammation in this region, although other bacteria, such as pneumococcus, bacillus proteus vulgaris, bacillus coli communis and various torulae may also be present.

Hyperaemia and swelling of the mucous membrane, although most marked in those regions where glands are present, viz. the pharyngeal end of the Eustachian tube, may also extend to the whole of the antro-tympanic cavity in severe cases. It is attended by an exudation of serum with leucocytes, and proliferation of the surface and glandular epithelium. Should leucocytes predominate, which is rare, the discharge will be opaque and purulent; if epithelial elements be chiefly active it will be viscid and tenacious, but probably clear; if serum be in excess it will be clear or watery, and thin in density. As a rule, the exudate is scanty in amount, there being practically no glands in the tympanum except near the ostium tubae. It differs from a true purulent exudate chiefly in degree, since the changes are mainly confined to the epithelial elements, and although polynuclear leucocytes are seen in the discharge they are relatively very few in number, and are not so numerous as in true suppuration.

Granular and vacuolated epithelial cells constitute the most striking cytological features, especially when the condition is chronic.

Usually the exudate is absorbed, but there is a great liability to recurring attacks, especially with narrow and paretic tubes, which favour chronicity, when the discharge becomes inspissated, tenacious, and mechanically interferes with sound conduction, ventilation, and drainage. Further, there is a liability to superadded infection of a more serious and purulent type.

Symptoms.—In acute cases pain is complained of, and in young children may cause considerable disturbance and restlessness. It is referred to the region immediately in front of the tragus, or along the course of the Eustachian tube. It may subside entirely after a few hours, only to reappear again should any fresh inflammation supervene. A feeling of fulness, numbness, and heaviness upon the affected side of the head is complained of, and, according to Politzer, is in inverse ratio to the degree of obstruction. Thus in those cases where the amount of deafness and swelling of the mucosa is only slight, the sensation of fulness in the head is well marked, whereas in those cases where deafness is severe and the obstruction of the tube well marked, little or no complaint is made. The temperature is usually only slightly elevated, and constitutional disturbances are not well marked, as in the suppurative type.

Tinnitus of varying pitch and intensity is also not infrequent. It may be continuous, although it is more usually intermittent, and varies with the severity of the inflammatory process and the amount of exudation present. When persistent and unrelieved by inflation, it must be regarded as an unfavourable symptom, and indicative of commencing organic changes in the neighbourhood of the labyrinthine windows.

Crackling noises and that peculiar sound, so frequently heard as when two moist surfaces are suddenly separated from one another, are also common, as is also autophony or hearing one's own voice in the affected ear. This latter symptom is more frequently complained of in unilateral otitis media, and when Eustachian obstruction is not complete. It is, as a rule, relieved by inflation, and disappears entirely after subsidence of the catarrhal symptoms.

In bilateral cases, when tubal obstruction is great and deafness correspondingly severe, a state of apathy and mental hebetude is induced. This condition of *aprosexia* (Guye) is especially common in children and amongst those suffering from middle-ear catarrh, the result of naso-pharyngeal adenoids. It rapidly disappears after removal of the vegetations and recovery of normal hearing power.

The degree of deafness depends upon the duration of the disease, the amount of exudation present, the localisation of the inflammatory process, atmospheric conditions, and the state of the general health. The longer the disease has lasted the more the liability to permanent organic changes in the mucosa. Rapid and at times almost instantaneous improvement in hearing, accompanied by a loud report or crack, occasionally takes place from sudden opening up of a previously obstructed tube or escape of thick mucus from its pharyngeal orifice, followed at times by a varying amount of *hyperaesthesia acustica.* More usually, however, improvement takes place gradually as the exudation becomes slowly absorbed, and as the normal ventilation of the tympanum is re-established.

On dry clear days and in summer the hearing power is generally better than in damp foggy weather, and in winter. It varies also according to the state of health of the individual. Any increase of an already existing naso-pharyngeal catarrh increases the amount of deafness, as does also excessive smoking, over indulgence in alcohol, and constipation. Such exacerbations may be sudden or may come on insidiously.

Paracusis Willisii, or hearing better in a noise, is sometimes complained of, although not as frequently as in cases of dry middle-ear catarrh and oto-sclerosis.

Examination with tuning forks in uncomplicated cases shows that the sound is lateralised to the affected ear (Weber), and in cases of bilateral disease to the ear more severely implicated. The duration of bone conduction for both high and low tones is normal, and in many cases is even exaggerated. If, however, a co-existing labyrinthine lesion be present bone conduction is impaired to a greater or less degree, and sound is lateralised to the non-affected side. In children, shortening of bone conduction should always lead to a suspicion of the presence of congenital labyrinthine syphilis (Politzer). In cases where exudation is slight Rinné's test is positive; when, on the other hand, the tympanum is full of exudation, and the Eustachian tube markedly obstructed, it is negative.

Diagnosis.—A diagnosis of exudative catarrh of the middle ear is made from an objective examination of the membrana tympani, and from the discovery of fluid within the tympanum. In cases when the membrane is thickened and opaque as the result of previous inflammatory attacks, and when it is not possible to see the existence of exudation, its presence may be inferred from the history of the case, the rapid improvement after the use of the air douche, and from the various sounds, crackling, bubbling, etc., conveyed by the auscultation tube to the observer's ear as the result of inflation. A positive diagnosis in such cases is, however, only possible after incision of the membrane, followed by the escape of fluid.

Prognosis.—In simple uncomplicated cases the prognosis is good, more especially if the exuded fluid be serous, and if the patient be healthy, and his surroundings good. Residence in damp, ill-ventilated, and badly lighted rooms materially retards recovery and favours relapses. Rapid and continuous improvement after the use of the air douche is a good prognostic sign, whereas a slight and only temporary increase of hearing after inflation is to be regarded as an unfavourable indication. Other unfavourable signs are the frequent recurrence of exudation, the presence of chronic hypertrophy of the naso-pharyngeal mucosa and of post-nasal growths, enlarged faucial tonsils, sinusal disease, paralysis of the muscles of the soft palate, the presence of a cleft palate, syphilis, excessive indulgence in alcohol and tobacco, and the presence of any wasting disease.

Objective Indications.—In recent cases, where no thickening of the membrane is present, the exudation may be visible, and presents a straw-yellow colour. In cases of longer standing, and in those where a considerable amount of mucous exudation co-exists, both the colour and the fluidity of the secretion vary within wide limits. Should the amount of exudation be insufficient to fill the tympanic cavity its upper limit is marked by a sharply defined dark line, concave, convex, or wavy, running horizontally across the membrane (Fig. 100).

At times the exudation presents a triangular appearance, the apex of the triangle being situated at the umbo. When fairly fluid it is influenced by movements of the head. Thus, if the head be moved slowly backwards, the level of the fluid rises up anteriorly upon the surface of the membrane, while posteriorly it sinks down. Conversely, if the head be lowered the fluid rises up posteriorly and sinks down anteriorly.

In certain cases the fluid is visible only through the anterior segment of the membrane, the posterior segment being opaque; in other cases the reverse holds good.

When the tympanic cavity is full of exudation no line is visible, but the membrane presents a yellowish appearance, due to the presence of secretion behind it. When the exudation is thin and serous, inflation churns it up and distributes it over the interior of the tympanum, with the result that a number of dark-coloured bubbles are seen scattered over the surface of the membrana tympani. These bubbles move up and down, disappear from view, or coalesce, and reproduce the appearance observed before inflation was practised.

Treatment.—In the treatment of secretory catarrh of the middle ear attention should first of all be paid to the state of the nasal and naso-pharyngeal mucosa, to the general health and habits of the individual, and to his surroundings. Catarrhal inflammation of the mucosa of the upper respiratory tract should be treated upon the principles already laid down (p. 517), special attention being directed to the condition of the *primae viae*, diet, exercise, and clothing.

Local treatment of the middle ear necessitates re-establishment of the patency of the Eustachian tube, the removal of secretion from the tympanic cavity, and the treatment of its inflamed mucosa, or of those local factors which are responsible for the persistent transudation of fluid.

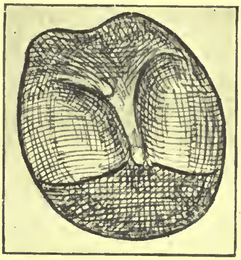

FIG. 100.—Sero-mucous exudation into the tympanic cavity.

To re-establish the patency of the Eustachian tube, inflation of air or of medicated vapours, *e.g.* chloroform, acetic ether, terebene, etc., by means of the air douche (Politzer), is called for, and is, as a rule, successful, except in those cases in which the lumen of the tube is so stenosed as to call for the passage of the Eustachian catheter after thorough cleansing of the nose and naso-pharynx. Politzerisation is best effected during the act of swallowing or at the moment when, with the mouth closed, the cheeks are fully blown out. In uncomplicated cases the entrance of air into the middle ear restores the mechanism of hearing instantaneously. The longer the improvement lasts the better the prognosis. Conversely, should the improvement be of short duration the inference to be drawn is either that the catarrhal process still continues or that the exudation is of such a tough and viscid consistence as to be incapable of absorption. In many cases an improvement in hearing will last for two or three days only to relapse again. As improvement takes place, however, the necessity for frequent inflation becomes less and less.

Persistent inflation at intervals of two or three days, combined with attention to the primary cause of the Eustachian obstruction, will, in a large number of cases, effect a permanent cure.

On the other hand, should stenosis of the tube be severe, it may be necessary first of all to pass the Eustachian catheter, employing the air douche for subsequent inflation.

The objections urged against the use of the catheter as a routine method of treatment are that it acts as an irritant when introduced into the mouth of an inflamed tube, and consequently tends to increase exudation, while in the case of children its passage is apt to cause pain and fright. It is also the means of at times introducing bacteria into the tympanum. While inflation by means of the air douche is, as a rule, all that is necessary in children and young adults, the employment of the catheter in elderly people and when the lesion is unilateral has, in the writer's hands, proved eminently successful.

The employment of the catheter is also necessary when it is deemed advisable to inject medicaments into the tube or middle ear.

Inflation, whether by Politzerisation or catheterisation, should be followed by gentle rarefaction of the air in the auditory meatus by means of Siegle's pneumatic speculum or Delstanche's rarefacteur in those cases where the membrana tympani is retracted.

The re-establishment of the patency of the Eustachian tube and the dispersal and subsequent absorption of fluid within the middle ear, besides improving the existing deafness, relieves the feeling of fulness and heaviness in the head, while in children the dull, listless, and apathetic mental state rapidly disappears. Occasionally massage of the ear and adjacent parts facilitates the absorption of sero-mucous exudation.

The removal of secretion from the cavity of the tympanum is called for in those cases when it is so tough and viscid as to be incapable of absorption, when it is exuded in large amount, when, after persistent inflation for a few days no diminution is visible, and in those cases of middle-ear deafness where, even if no secretion is demonstrable, an improvement in hearing takes place after inflation only to relapse in the course of a few hours or days. Before incising the membrane in order to evacuate the contents of the middle ear, the nose and mouth should be disinfected by means of an alkaline antiseptic spray solution, and the auditory meatus carefully cleansed, first by syringing with warm carbolic lotion (1 in 40), and subsequently by the instillation of peroxide of hydrogen solution (3 per cent). The knife used for incision, mounted upon a handle with the ordinary aural angle and made of highly tempered steel and very sharp, should be rendered aseptic by immersion in absolute alcohol. The incision should be made in the postero-inferior or antero-inferior segment, and may be vertical, horizontal, or crescentic.

As a rule, a vertical incision in the postero-inferior segment is that most easily made. Should the membrane be bulged as the result of accumulation of fluid behind it, the incision should be made through the the centre of its convexity. Great difficulty is experienced in preventing cicatrisation of the edges of the incision, whether vertical or horizontal. To minimise this tendency the writer is in the habit of making two incisions in the shape of a St. Andrew's cross through the most bulging portion of the posterior segment. The incision should be made as long as possible so as to permit of the free escape of the contents of the tympanum, which are at times extremely viscid and tenacious.

To relieve pain the membrane should be anaesthetised by the local application of cocaine-aniline solution. As large and as short a speculum as possible is inserted into the meatus, which is then well illuminated from the forehead mirror. The knife held between the thumb and first and second fingers of the right hand is introduced through the speculum and rapidly plunged through the membrana tympani. As it is withdrawn it is made by an upward inclination of the handle to cut downwards for a distance of from 2 to 4 mm. so as to fully incise the membrane, or by depressing its handle to cut upwards. Care should always be taken to avoid injury to the walls of the meatus. The risk of doing so is lessened when the horizontal incision is made (Bing).

When the floor of the middle ear is dehiscent and when the jugular bulb rises up into the cavity of the tympanum, severe haemorrhage may result from its accidental injury. Rapid and firm tamponing of the auditory meatus serves, as a rule, to arrest the profuse flow of blood. If prior to incision a dark bluish-black shadow is seen through the lower segment of the membrane, great care should be exercised and a horizontal incision made.

After incision the tenacious and glairy mucus will be seen through the now gaping incision, at times pulsating, at other times endeavouring to exude into the meatus. Should it be thin and serous it may percolate slowly into the meatus, especially if assisted by the performance of the Valsalvan experiment. If thick and viscid its removal should be effected by means of inflation with the air douche combined with a Sondermann's suction apparatus. By bending the head downwards and slightly forwards escape of fluid is to some extent assisted.

Compression of the air in the auditory meatus followed by sudden rarefaction is at times of assistance, while in exceptional cases when the exudation cannot be drawn outwards it may, by forcible compression, be driven into the naso-pharynx *per* the Eustachian tube. The mucus which escapes or which is driven into the auditory meatus should be mopped up with pledgets of sterile wool or removed with strips of sterile gauze. Syringing is to be avoided on account of the risk of infecting the middle ear.

After as much of the exudation has been got rid of as is possible the meatus should be lightly packed with iodoform gauze. To endeavour to keep the lips of the incision from cicatrising the patient should be instructed to perform the Valsalvan experiment four or five times during the day. Inflation with the air douche should be practised every day or every second day. Notwithstanding this, the incision is extremely prone to close, often doing so within twenty-four hours. Should it heal before exudation has ceased to form it is necessary to re-incise. Re-incision may have to be repeated frequently in exceptional cases. Provided that thorough antiseptic cleansing of all neighbouring parts has been adopted prior to incision and that syringing has been avoided, consecutive inflammation of the middle ear is unlikely to take place. Should no recurrence of exudation take place, the membrana tympani rapidly regains its normal appearance, and within a few weeks it is frequently impossible to see where the incision has been made. At other times the scar is distinctly visible for months, and even years, afterwards. At times a patch of atrophy marks its original position.

One incision is at times sufficient to effect a cure, especially in those cases where the catarrhal process has come to an end and only the exudation remains to be dealt with.

When, on the other hand, the catarrhal inflammation is still in progress and the incision heals rapidly, re-incision on several occasions is frequently necessary. In such cases the writer is in the habit of perforating the membrane with a fine galvano-cautery point. The perforation so produced remains open much longer than that made by incision, and consequently acts as a more efficient means of drainage. It is, however, a more difficult and more painful procedure, and should only be undertaken by those thoroughly conversant with aural technique.

In many cases recovery of hearing after incision of the membrane and evacuation of the contents of the middle ear is rapid and permanent; in others, owing to swelling of the mucosa of the Eustachian tube and middle ear, anomalies of tension of the sound-conducting apparatus, adhesions, or implication of the labyrinth, continuous treatment is required before any permanent improvement is attained. An oedematous condition of the tube is diagnosed after the passage of the Eustachian catheter and noting the auscultatory sounds, or by the careful employment of the Eustachian bougie. The greater the difficulty with which air enters the middle ear and the higher pitched the resulting note the greater the stenosis of the tube.

Anomalies of tension of the sound-conducting apparatus are diagnosed by noting the amount of improvement after inflation, followed by rapid deterioration so soon as the membrane resumes its former position, while the existence of adhesions between the ossicula auditus or between the footplate of the stapes and the margin of the fenestra ovalis are almost certain, if after having emptied the tympanum of its fluid contents no improvement in hearing takes place after free inflation, and tinnitus still remains.

Labyrinthine involvement is diagnosed as the result of careful examination with tuning-forks, by the presence of a positive Rinné, and from the fact that the patient hears perceptibly worse in a noisy place.

To overcome the swelling and oedema of the mucous membrane lining the Eustachian tube, which often remains after evacuation of the contents of the middle ear, the injection of medicated fluids through the Eustachian catheter is useful. After having cocainised the nasal passage the catheter is passed and the ear inflated with air. A few drops of the medicament to be employed, after having been slightly warmed, are injected into the catheter from a Pravaz syringe, and then driven into the tube by pressure of a rubber bulb or balloon. In cases of severe stenosis, inflation practised during the act of swallowing materially assists the entrance of fluid into the middle ear.

The following solutions are useful as injections, viz. sterilised liquid vaseline, tannic acid (1 to 2 per cent), Burow's solution (1 to 5) and in more severe cases, nitrate of silver (2 per cent) preceded by the injection of bicarbonate of soda (gr. iii. to ℥ i.), or iodide of potash (gr. iii. to ℥ i.). When air enters the middle ear with very great difficulty, even after forcible inflation with the air douche or through the catheter, medicated bougies may be employed for the purpose of dilating the stenosed tube. Catgut, celluloid, or whalebone bougies may be employed, and may before introduction be soaked in any medicament which it is desired to use. Before passing the bougie, the exact length of the Eustachian catheter should be marked upon it. The catheter is then passed and the ear inflated. The bougie is now passed along the catheter, as far as the mark originally made upon it, when both catheter and bougie will be found lying in the mouth of the Eustachian tube. It is then very gently pushed forwards up the tube, the distance varying according to the amount of resistance encountered, and is held *in situ* for two to three minutes so as to give the medicament a chance of acting upon the inflamed and oedematous mucosa.

After a few day's treatment, the tube may have become so sufficiently opened up as to admit of inflation being successfully performed with the air douche.

In addition to local treatment, change of air, especially to a high, dry, and bracing climate, the avoidance of alcohol and tobacco, a mild and easily digested diet, and a course of saline aperients and calcium hypophosphite are indicated in troublesome and protracted cases.

SEQUELAE—(*a*) **Catarrhal Inflammation of the Eustachian Tube.**—As the result of a cold in the head and consequent catarrhal inflammation of the post-nasal mucous membrane, the Eustachian tube may become blocked from swelling of its walls, or from a plug of inspissated mucus (Fig. 101). In such cases the patient complains of a feeling of fulness and numbness over the affected side of the head, deafness, and occasionally tinnitus. In favourable cases, as the existing catarrhal inflammation subsides, the Eustachian tube opens up of itself, the opening being accompanied by a loud click ; in other cases, however, it remains closed with persistence of symptoms.

Objective examination of the membrana tympani may show nothing more than very slight retraction and occasionally slight congestion. Examination of the naso-pharynx reveals the presence of a catarrhal inflammation, swelling, and oedema of the mucous membrane, and bands of stringy mucus. The mouth of the Eustachian tube may also be seen at times to be occluded with a plug of inspissated mucus.

Treatment.—Rest in bed or indoors, a warm bath, the administration of Dover's powder and a saline purge frequently serve to arrest the naso-pharyngeal catarrh, and consequently the tubal catarrh. Gentle irrigation of the nasal passages with a mild alkaline antiseptic lotion is also useful. To re-establish the permeability of the tube inflation by means of Valsalva's method may be tried. Should this fail, inflation with Politzer's air douche will succeed in practically all cases. This failing, inflation should be effected by the passage of the Eustachian catheter. Reopening the tube and the re-establishment of the ventilation of the middle ear are at once followed by relief.

Repeated attacks of tubal catarrh may, however, lead to organised changes in the submucous connective tissue with the result that a fibrous stricture is produced.

(*b*) **Purulent Inflammation of the Eustachian Tube.**—In certain cases of suppurative middle-ear disease, accompanied by perforation of the antero-inferior segment of the membrana tympani, and by the presence of a muco-purulent exudation, the lining membrane of the Eustachian tube becomes infected. In such cases the tube is, as a rule, permeable, and fluids introduced through the meatus may pass readily into the naso-pharynx. Pus may also occasionally be seen upon posterior rhinoscopy to ooze from the mouth of the tube.

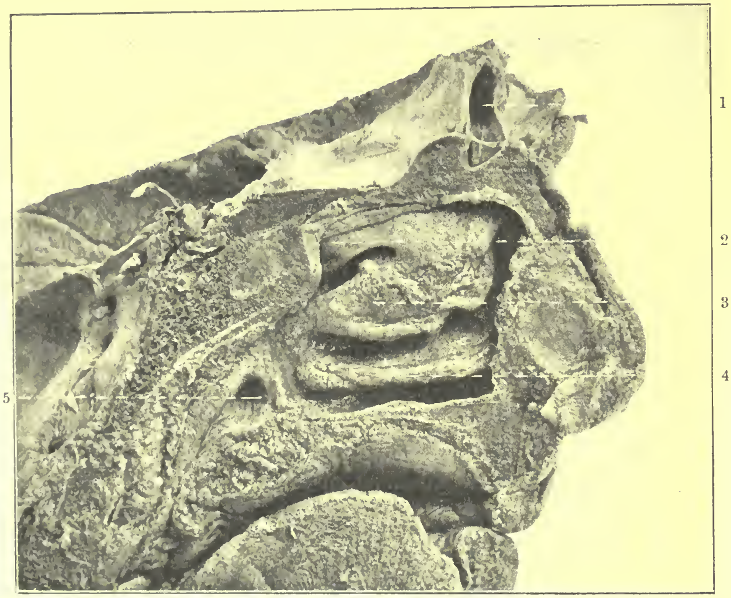

FIG. 101.—Section of nose (wet preparation) showing the ostium tubae Eustachii and its relation to the posterior end of the inferior turbinated body. (1) Frontal sinus, (2) superior turbinal, (3) middle turbinal, (4) inferior turbinal, (5) Eustachian tube.

Treatment.—Inflation should first of all be accomplished, followed by the injection through the Eustachian catheter of a weak solution of nitrate of silver (gr. 2 to 3, oz. 1), or a bougie smeared with iodoform ointment should be passed into the tube and allowed to remain *in situ* for a few moments.

(*c*) **Stricture of the Eustachian Tube.**—A stricture of the Eustachian tube may be temporary or permanent. It may be due to a localised or diffuse swelling of its mucous membrane, or to the presence of organised connective tissue, the result of submucous hyperplasia or inexpert removal of adenoids. The most usual site of stricture of the tube is at the junction of its bony and cartilaginous portions—the isthmus of the tube. A stricture may also occur about the mouth of the tube, as the result of the presence of a new growth in the naso-pharynx, or gummatous or malignant ulceration of the lateral naso-pharyngeal wall. Occasionally stricture of the osseous portion of the tube results from hyperostosis of its walls, or from abnormal position or development of the carotid canal. Repeated attacks of tubal catarrh, and more especially of suppurative tubal catarrh, lead at times to the formation of granulation tissue masses which, adhering together, form very impermeable strictures.

Symptoms.—Stricture of the Eustachian tube gives rise to various subjective and objective symptoms. The subjective symptoms are, fulness in the head upon the same side, deafness, and tinnitus. The objective indications are the presence of a retracted membrane, mucus in the middle ear, and a more or less impermeable tube, as indicated by the difficulty attending inflation of the middle ear. In cases where the canal is narrowed by swelling and oedema of its mucous membrane, inflation with air is rendered difficult. Its entrance into the tympanum, as ascertained by means of the auscultation tube, is delayed. Once air enters the tympanum, however, the sound produced is fairly characteristic and is accompanied by mucous râles. When the stricture is very tight, the sound is high-pitched and hissing, in other cases rough and rasping.

Diagnosis.—The diagnosis of stricture is made mainly as the result of inflation tests. The difficulty of effecting an entrance of air into the tympanum, either by means of Politzer's air douche or the Eustachian catheter, and the "far away sound" as revealed by the auscultation tube, indicate, as a rule, the presence of marked stenosis. This is farther emphasised by the difficulties attending the passage of the Eustachian bougie.

Treatment.—In simple cases of catarrhal swelling of the mucous membrane, the frequent use of Politzer's air douche, combined with irrigation of the post-nasal mucosa with a warm alkaline antiseptic lotion, is often sufficient to effect a cure. The injection of a few drops of cocaine-adrenalin solution, through the Eustachian catheter, by contracting the engorged blood vessels, often permits of subsequent successful inflation, and moreover assists in the diagnosis between a temporary and an organised fibrous stricture.

In many cases, however, it is necessary to pass the Eustachian bougie in order to overcome the resistance offered by the stricture. Celluloid, silk-worm gut, or whalebone bougies may be employed according to circumstances. A short and curved catheter is first passed as far up the mouth of the tube as possible. The bougie, smeared with vaseline and marked to show the length of the catheter, is passed rapidly through the catheter until the mark is reached, and is then insinuated slowly and carefully up the tube, gentle pressure being exercised to overcome the resistance offered to its passage. Great care should be taken not to wound the mucous membrane or to make a false passage. Repeated attempts may be necessary to guide the bougie through the stricture. When ultimately it does pass, a sharp pain is, as a rule, felt in the ear and over the occiput.

To assist dilatation, the bougie should be left in position for from five to ten minutes. Subsequently a stream of air may be injected into the tympanum.

The treatment of cicatricial stricture is seldom satisfactory. Even should the surgeon succeed in passing the bougie, recurrence of symptoms is almost certain to take place within a few months, owing to the contraction of the connective tissue forming the stricture.

Possibly the repeated injection of a few drops of fibrolysin might prove of benefit in such cases, but of this the writers have no experience.

CHAPTER XV

OTITIS MEDIA CATARRHALIS CHRONICA

Chronic Adhesive Catarrh of the Middle Ear.—Chronic adhesive catarrh of the middle ear is a progressive disease of the middle-ear cleft, the result of attacks of secretory catarrh, and is characterised by dry sclerotic changes, causing deformity of the sound-conducting apparatus.

Aetiology.—The principal causes are :—

1. Repeated attacks of exudative catarrh of the tubo-tympanic lining induced as the result of naso-pharyngeal catarrh, naso-pharyngeal adenoids, catarrhal or atrophic rhinitis.
2. Repeated exposure to cold.
3. Residence in damp and unhealthy surroundings.
4. Over-indulgence in alcohol and tobacco.
5. Pregnancy and the puerperium.
6. Rheumatism, gout, syphilis, Bright's disease, anaemia, chlorosis, tuberculosis.
7. Paresis or paralysis of the muscles of the soft palate and Eustachian tube interfering with the normal ventilation of the cavum tympani, *e.g.* post-diphtheritic paralysis.
8. Hereditary predisposition.

More than one of the above-named causes may act upon the ear at one and the same time. Whereas in children and young people the exudative form of catarrh is most frequently met with, in adults and in those of mature age adhesive changes are more common.

In one ear secretory catarrhal changes may be taking place, while in the other suppurative inflammation or adhesive otitis media may be present. When both ears are affected the progress of the disease is rarely uniform. The ear which is the second to be attacked is, as a rule, the ear in which progressive loss of hearing is more rapid, and ultimately the more pronounced. Exacerbations of deafness are frequent. The disease is almost invariably progressive although temporary amelioration may at times take place. In exceptional cases the development of an acute *otitis media* on the top of an adhesive catarrhal inflammation brings about permanent improvement. In many cases the adhesive changes which take place in adult life are due to neglected exudative catarrh in childhood and to the want of attention to its primary and exciting cause.

Pathology.—The morbid changes are generally regarded as the legacies of repeated attacks of acute or subacute catarrh, in which the connective tissue or mesoblastic elements have played a more prominent part than the surface or glandular epithelium. Such changes are characterised by a permanent thickening of the muco-periosteum, contraction and deformity of the ligamentous folds of the tympanum, the ossicles and their articulations, and alteration in the texture of the tympanic membrane, a group of changes which interferes with the conduction of sound-waves from the tympanic membrane to the labyrinthine fluid and nerve terminals.

Histological evidence of the actual transition from one stage to another is necessarily scanty, from the difficulty in obtaining reliable material. A sufficient number of observations have, however, been made to fully establish the nature and identity of the disease in its advanced stages. Of the pathology of the early periods of the disease but little is known. The tympanic mucosa may be red and moist, later it becomes dry and pale. The inflammatory process may be restricted to only a small area or may be diffuse, involving the whole antro-tympanic cavity, the antrum and pneumatic cells having even been seen to contain oedematous tissue and viscid fluid. It is, therefore, not surprising that the disease presents such wide and varied clinical characteristics.

As a result of early leucocytic activity the subepithelial layer of the muco-periosteum becomes rich in "wander" cells mixed with lymphocytes, plasma, and endothelial cells, which also involve the ligamentous folds of the lining membrane. The region of the fenestrae is much affected, but the most marked changes are where the tympanic lining is thickest and the glands most numerous, as in the Eustachian tube and around its tympanic ostium.

This sometimes leads to such extensive deformity as to suggest that a much more intense process than simple catarrh must have been at work, although it is extremely difficult either clinically or pathologically to define the line of demarcation between catarrhal and phlogogenic processes. Many cases are so closely associated with gouty and other troubles of an arthritic nature that ossicular and ligamentous changes are not surprising and almost demand a special grouping.

Although synostosis of the stapedio-vestibular region is also a characteristic of oto-sclerosis, that disease is, however, primarily one of the labyrinthine capsule, while the disease under consideration is essentially a catarrhal one, beginning in the tympanic mucosa. In view, therefore, of the markedly sclerotic and hypertrophic character of the lesions often found in this disease one cannot accept, without some reservation, that they are all due to a simple catarrhal inflammation.

That the cochlear and vestibular windows are so frequently involved is not at all surprising in view of their anatomical arrangement, which renders them peculiarly liable to obstruction from swelling of the muco-periosteum (p. 435).

The histological changes are of three kinds: (1) thickening of the surface epithelium, (2) sclerosis and hypertrophy of the deeper or connective tissue structures, and (3) atrophy. These changes may occur separately or collectively.

The lining epithelium is usually much thickened until a very late stage, but does not become typically squamous unless attended by perforation of the tympanic membrane. Sections of the deeper layers of the thickened muco-periosteum and folds show dense sclerotic white fibres entangling small elongated or fusiform nuclei, the relics of fibroblasts which were derived most likely from original connective tissue corpuscles, from epithelioid cells, or from lymphocytes. This tissue has a strong resemblance to keloid, with a variable supply of blood-vessels, which often exhibit considerable thickening of their walls. In the earlier stages plasma cells are to be seen.

As the disease progresses the sclerotic tissue contracts, vessels are more or less obliterated, and patches of calcific deposit are found alternating with areas of atrophy.

Thus the tympanic cavity is gradually reduced in size, and the Eustachian tube may be obstructed either by thickening of its lining membrane or by sclerotic contraction. This stenosis may be purely local, *e.g.* at the *ostium tympanicum* or diffused throughout its whole length. In the late stages of the disease the tube may be open in its entire length as in otosclerosis.

The ossicles may be the seat of arthritic changes with more or less distortion and anchylosis, or their movements may be limited by adventitious bands as described by Toynbee. The malleo-incudal seems to be the joint chiefly involved, the stapedio-incudal the least so. As already mentioned, synostosis between the stapes and the oval window is by no means rare, but the sclerotic changes are usually confined to the tympanic aspect, and do not extend far into the labyrinth, as in true oto-sclerosis. Movement of the ossicles may be farther limited by atrophic degeneration of the muscles, which may be primary or secondary.

The tympanic membrane presents considerable variations in texture, contour, and mobility. It may be opaque and thickened in one part, or thin and transparent in another. It may be puckered, rigid, or flaccid in part or wholly. Its normal lustre is wanting, it may exhibit patches of interstitial calcification and be firmly adherent to the promontory.

All the changes will obviously vary according to the relative predominance, intensity, and duration of the catarrhal and adhesive processes.

Subjective Symptoms.—The degree of deafness varies with the duration, extent, and situation of the connective tissue changes, and with the presence or otherwise of simultaneous implication of the labyrinth.

Deafness for speech is in general a pronounced feature. The power of hearing high tones and sharp, shrill noises is frequently retained for long periods. During mastication the degree of deafness is intensified. The hearing power is generally better in the morning than in the evening, and in dry weather than on damp and rainy days.

Tinnitus is almost invariable. Although frequently intermittent, it is prone to become continuous and to cause such severe depression as at times to lead to melancholia and even suicidal tendencies. It is aggravated by mental excitement, worry, over-indulgence in alcohol or tobacco, pregnancy, exhaustion, colds in the head, influenza, etc. When adhesive catarrh is complicated with oto-sclerosis, tinnitus is persistent and extremely distressing to the patient.

Severe tinnitus also results as the outcome of increased labyrinthine tension due to intra-tympanic changes. In such cases forcible inflation or aspiration affords temporary relief. Extension of pathological changes to the labyrinth, so common in the advanced stages of adhesive catarrh, leads to permanent and incurable forms of deafness and tinnitus.

Pain in the ear is unusual, except in those cases where intercurrent inflammatory attacks following cold in the head, etc., take place. *Hyperaesthesia acustica* is occasionally present. A feeling of fulness, accompanied at times by mental depression, is not infrequent. In exceptional cases sudden vertigo, accompanied by nausea or sickness and an increase of deafness and tinnitus, takes place, and is frequently due to vasomotor changes dependent upon such factors as constipation, menstruation, the climacteric, etc.

Objective Indications.—The objective indications of adhesive catarrh consist in thickening, opacity and retraction of the membrana tympani, fixation of the ossicular chain, and stenosis of the Eustachian tube.

In many cases the whole membrane is found thickened and of a dense white colour. In others the opacity is confined to its posterior segment or to the region of the annulus tendinosus.

Calcareous degeneration is not uncommon, the deposits sharply defined, irregular in outline, and of an opaque white colour, being situated, as a rule, in front of or behind the handle of the malleus, or united in the form of a horseshoe surrounding its umbo. They are due to the deposition of lime salts in the tympanic mucosa.

In exceptional cases numerous small opaque areas are found scattered over the entire surface of the membrane, giving it a peculiar mottled appearance. These are due to deposits of lipoid granules in and below the cutaneous epithelial layer.

The degree of retraction varies within wide limits, and depends upon the amount of Eustachian obstruction and its duration. The more retracted the membrane the greater the prominence of its anterior and posterior folds, especially the latter, and of the short process of the malleus (Fig. 102). The light reflex which, under strictly normal circumstances has the shape of an equilateral triangle, becomes more and more of the shape of an isosceles triangle, until finally, in extreme cases, its outlines are not to be distinguished. The membrane may become so retracted as to be in actual contact with the mucosa covering the inner tympanic wall and, finally, to adhere to it. More than one adhesion may exist. The appearance presented by an adhesion is that of a sharply defined round or oval depression surrounded by the opaque and thickened membrana tympani.

Prognosis.—The fact that in chronic adhesive catarrh of the middle ear definite connective tissue changes are present renders the prognosis a matter of gravity. The more defined these changes are, as evidenced by marked opacity of the membrane, fixation of the ossicular chain, and stenosis of the Eustachian tube, the worse the outlook. The shorter the duration of the disease, the less the degree of deafness, and the absence of implication of the auditory nerve terminals, the better the prospects. The prognosis is better in those cases in which tinnitus is either absent or intermittent than when it is continuous and of a high-pitched character.

When the existing deafness is relieved by inflation, and especially when the improvement is maintained for a few days, the prognosis is more favourable than when it produces no effect or a merely temporary one. The prognosis is essentially bad in those cases where there has been steady loss of hearing accompanied by loss of bone conduction, and absence of response to inflation by the catheter or by Politzer's air douche.

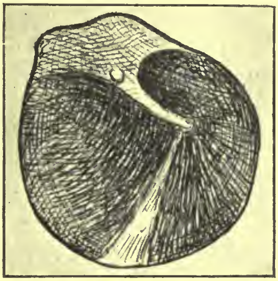
FIG. 102.—Chronic tubo-tympanic catarrh. Retraction of the membrane; foreshortening of the manubrium mallei; prominence of anterior and posterior folds.

The prognosis is also bad in anaemic, cachectic, and tuberculous patients, in old people, and in those with an hereditary tendency to catarrhal affections. Living in damp and insanitary surroundings, and certain occupations which predispose to catarrhal attacks, render the outlook unfavourable.

Differential Diagnosis.—Chronic adhesive catarrh should be carefully differentiated from true oto-sclerosis. In chronic otitis media there is usually a history of repeated catarrhal attacks and of the deafness being made worse in damp weather and when the patient has a head cold.

In true oto-sclerosis the process is independent of cold in the head and of climatic influences. The objective appearances presented by the membrane, in the former more or less thickened, dull, white, opaque and retracted, in the latter either normal in appearance and position, or presenting a flamingo-red tint in the region of the stapedio-vestibular articulation, are characteristic.

Chronic adhesive processes in the middle ear may set in at any age, whereas it is unusual to find true oto-sclerosis before the age of twenty.

The various tuning-fork tests, more particularly Gelle's, afford additional diagnostic information. In true adhesive catarrh Gelle's test is positive, and remains positive until the disease is far advanced; in oto-sclerosis it is from an early stage negative, while the presence of Bezold's symptom-complex (p. 471), viz.:—

1. Increase of bone conduction;
2. Negative Rinné;
3. Elevation of the lower tone limit;

is diagnostic of oto-sclerosis.

It should, however, be borne in mind that "mixed" cases of adhesive catarrh and oto-sclerosis are by no means uncommon.

Treatment.—The indications are to diminish if possible the existing degree of deafness, and to endeavour to arrest the cicatricial and fibroid changes which are taking place in the tubo-tympanic mucosa. Foremost amongst therapeutic measures must be placed inflation of the middle ear, either by means of Politzerisation or catheterisation. The injection of air into the middle ear acts beneficially by mechanical pressure upon the dilated venules, by stretching adhesions, and if repeated several times in succession by massaging the rigid ossicular chain. The greater the improvement in hearing and the longer its duration the better the prognosis. Where the pathological changes are confined mainly to the tympanic cavity, inflation by Politzer's method is indicated, whereas, when there is co-existing stenosis of the Eustachian tube, catheterisation is more effective. Instead of inflation with ordinary atmospheric air, the vapour of chloroform, ether, terebene, oil of eucalyptus or camphorated iodine may be employed when a stimulating effect is desired. To be effective, inflation should be practised every third or fourth day for a period of six weeks, and repeated for another period of six weeks after an interval of three weeks. Inflation may be combined with gentle rarefaction and condensation of air in the auditory meatus, or with the injection of fluids into the tympanic cavity, which, as the result of their solvent or irritative action, promote absorption of young unorganised round-celled infiltrations or newly formed connective tissue. Care must be exercised, however, that the resulting reaction is not too severe. The fluids employed for the purpose are solutions of bicarbonate of sodium (gr. iii.-℥i.) bicarbonate of potassium (gr. ii.-℥i.) iodide of potassium (gr. ii.-℥i.) muriate of pilocarpine (♏ iii.-℥i.) fluid vaseline, chloride of sodium, nitrate of silver, fibrolysin.

Injections of fibrolysin have been extensively tried and with varying results.

In a series of 47 cases of dry middle-ear catarrh treated by Gay French,[1] tinnitus was present in 36 and absent in 11 cases. Of the 36 cases with tinnitus 11 were complete failures, and 8 showed no improvement in hearing although tinnitus was diminished; in 17 hearing was improved (6 with no diminution of tinnitus, 8 with diminution, and 3 with complete cessation); of the 11 cases without tinnitus, in 7 there was an improvement in hearing, and in 4 there was none.

The method adopted was to inject twice a week for six weeks 30 mgr. of fibrolysin subcutaneously into the arm and 5 mgr. into the tympanum through the catheter. The results obtained by the writers with fibrolysin and with thiosinamin have, although at times producing a temporary improvement, proved most disappointing.

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[1] *Lancet*, July 24, 1909.

To what extent the injection of such fluids aids in arresting fibroid changes is doubtful, a very considerable proportion of the improvement being in all probability due to the mechanical effects of inflation. The employment of air under pressure and of warmed air (Ferran)[1] is highly spoken of by some writers.

Definite advantage appears to the writers to accrue from a course of intra-tympanic injections of compressed and heated air followed by a course of vapour inflations and accompanied by pneumo-massage. To be effective massage should be very gently applied, and for not more than one minute at a time. Massage with Lucae's pressure-probe causes such pain and discomfort that few patients will tolerate its application. If employed, the membrane should be well anaesthetised with cocaine-aniline solution.

So long as local treatment, whether by inflation or by intra-tympanic injections, produces an improvement, it may be continued. When, on the other hand, a point has been reached beyond which no improvement takes place, the treatment should at once be stopped. Clinical experience shows that pushing the treatment beyond the point of maximum improvement tends to cause definite retrogression. The duration of the improvement varies greatly, but in no case is it permanent. Consequently it is necessary to repeat one or other method of treatment periodically for a few weeks once or twice a year. Such courses of after-treatment at suitable intervals exercise a distinct tendency in helping to arrest the progress of the disease. The value of auto-massage, auto-inflation, vibration from cycling, use of instruments, etc., is very problematical.

In cases of adhesive catarrh occurring in anaemic, strumous, syphilitic, and debilitated subjects, suitable internal medication should be adopted, such as the administration of iron, arsenic, phosphorus, iodide of iron, iodide of potassium, etc.

The application of counter-irritants over the mastoid process is regarded by some authorities as of value, by others as of no use whatever. The writer is convinced that counter-irritation, *e.g.* the application of blistering fluid, liniment of iodine, iodine ointment, etc., is of value if persisted in regularly for long periods.

The instillation of medicated fluids into the external ear and the application of ointments to the walls of the auditory meatus is to be strongly deprecated.

In the treatment of both the exudative and adhesive forms of catarrh of the middle ear, attention should be directed to the character of the patient's occupation, to diet, clothing, consumption of alcohol and tobacco, and to his surroundings.

When work is carried on in damp, ill-ventilated and ill-lighted rooms, a change to some other form of occupation is advisable if possible. Working in the midst of loud noises, *e.g.* boiler-making, riveting, etc., is also inadvisable on account of the secondary labyrinthine changes thereby induced, which seriously complicate the existing middle-ear lesion. Rich food, condiments, etc., should be avoided, the diet being confined to light, easily-digested, and assimilable food. Alcohol and tobacco should be used sparingly, especially in those cases where they are found to induce pharyngitis and naso-pharyngeal catarrh, and should be entirely cut off when they cause an increase of tinnitus and pressure in the head. Silk or woollen underclothing should be worn. If possible, the patient should live in a high, dry, and bracing atmosphere, and in well-ventilated and well-lighted rooms with a southern aspect.

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[1] *Journal of Laryngol.*, August 1909.

Hill air should be selected in preference to sea air, which, in the writer's experience, is distinctly harmful in such cases. Regular exercise in the open air is advisable, but on wet and windy days the patient should, if possible, remain indoors.

Cold water baths are permissible provided that care be taken to avoid the head douche and diving. In anaemic individuals, amongst those whose skin does not react, and in patients with a strong hereditary tendency to catarrhal adhesive deafness, cold water baths are contra-indicated. Hot baths taken once or twice a week at night or a Turkish bath once a fortnight are distinctly advantageous, promoting as they do a healthy reaction of the skin, inducing increased resistance, and diminishing a tendency to catch cold.

In the secretory forms of catarrh where treatment fails to arrest the constantly recurring exudation, a change of air to a dry and bracing climate has frequently a most favourable influence. Similarly, amongst those who suffer from repeated attacks during the damp and cold months of winter and spring, a change to a dry and sunny atmosphere is very advantageous. Various alpine resorts such as Arosa, and such places as Assouan, Biscra, are suitable.

Although change of air has not the same effect in the adhesive forms of catarrh as it has in the exudative, it is frequently worth while advising residence in a dry and mountainous district during the winter months, or in some warm and mild southern health resort.

When some constitutional disease such as struma, rickets, rheumatism, gout, syphilis, or anaemia is present, residence at some suitable Spa is, if circumstances permit, advisable. For strumous and rachitic patients the waters of Kreuznach are suitable. For rheumatic cases, Aix-les-Bains; for syphilitic cases, Aix-la-Chapelle; and for anaemic cases, Levico, Woodall Spa.

Treatment of the Nasal and Naso-pharyngeal Mucosa. — Attention should invariably be directed to the state of the nasal and naso-pharyngeal mucosa. Pathological conditions which interfere with the mechanism of the Eustachian tube and the ventilation of the middle ear should, if possible, be removed, and catarrhal conditions treated by suitable lavage, alkaline antiseptic spray solutions, or the application of astringent pigments. Purulent disease of the nasal accessory sinuses, the presence of oral sepsis, carious teeth, and septic inflammation of the supra-tonsillar fossa demand also thorough investigation and treatment.

The Operative Treatment of Chronic Adhesive Catarrh of the Middle Ear.—From time to time various operative procedures have been devised in the hope that by removing adventitious tissue which prevents the free ingress of sound waves to the stapedio-vestibular articulation, the power of hearing might thereby be materially improved.

Unfortunately, the results obtained leave much to be desired, so much so that the majority of aural surgeons now rarely resort to anything more than merely constitutional and local treatment.

Before undertaking any operative procedure it is necessary to ascertain the exact condition of the internal ear by careful testing with tuning-forks and by the use of Galton's whistle. If it can be shown that the function of the auditory nerve is intact and that the pathological lesions are confined to the sound-conducting apparatus, some relief following division of adhesions, removal of a thickened membrane, or of anchylosed ossicles might reasonably be expected. Unfortunately, relief, if obtained, is seldom lasting, and in some cases is followed by an actual increase in the amount of deafness.

The various intra-tympanic operations are :—

1. Artificial perforation of the membrana tympani.
2. Division of the posterior fold of the membrana tympani.
3. Removal of a segment of the membrana tympani.
4. Tenotomy of the tensor tympani muscle.
5. Tenotomy of the stapedius muscle.
6. Removal of the membrana tympani, malleus, and incus.
7. Mobilisation of the stapes.
8. Division of fibroid adhesions uniting the foot-plate of the stapes to the margins of the fenestra ovalis.
9. Extraction of the stapes.

Artificial Perforation of the Membrana Tympani.—All efforts to maintain the patency of an artificial perforation of the membrana tympani have so far proved unsuccessful. A certain degree of improvement is noted in many cases so long as the artificial perforation remains open. Its closure is, however, frequently marked by an actual decrease in hearing power. An artificial perforation may be made for purely diagnostic purposes, as a means of temporary treatment, *e.g.* the injection of fluids into the tympanic cavity, or as a means of endeavouring to improve the hearing power by providing a direct passage for sound waves to the outer labyrinthine wall, or of equalising the pressure upon the two surfaces of the membrana tympani. The indications for its performance are :—

1. The presence of a thickened, opaque, and retracted membrane.
2. The presence of extensive calcification of the membrane.
3. The presence of an extremely retracted membrane associated with chronic Eustachian obstruction.
4. Anchylosis of the *ossicula auditus* to one another or to the tympanic parietes.
5. In cases of severe tinnitus.

6. As a means of obtaining access to the tympanum for the performance of such operations as the division of adhesions, mobilisation of the stapes, extraction of the stapes, etc.

Perforation may be accomplished by means of a crucial incision, by removal of a triangular segment of the membrane, by excision of the manubrium mallei and adjacent portions of the membrane, or by perforation with caustics or with a fine galvano-cautery point. Incisions, from the rapidity with which they heal, are comparatively valueless, and the same may be said of the other methods, with the exception of galvano-caustic puncture, which has been proved by practical experience to be the best and the most lasting.

After having anaesthetised the membrane with cocaine-aniline solution, a fine galvano-caustic point is passed down in contact with the membrane. The circuit is at once completed and the point gently pushed forward, great care being taken to prevent its coming in contact with the inner tympanic wall. The sites of election for perforation are the postero-inferior and antero-inferior segments, especially the former. The circular opening thus made will be found to remain patent for several weeks, during which time there is frequently an improvement in audition and a diminution of subjective noises in the head. Occasionally a secondary suppurative catarrh is set up, followed by an improvement in hearing and by the production of a permanent perforation due to epithelialisation of the edges of the original artificial opening. The introduction of various artificial devices such as plugs, pegs, wire, eyelets, etc., has proved quite unavailing, the gradually contracting perforation forcing the foreign body out with or without the production of suppuration.

Division of the Posterior Fold of the Membrana Tympani.—This operation, which was originally proposed by Politzer,[1] is designed to secure greater mobility of the handle of the malleus and to relieve the tension of the markedly retracted posterior segment of the membrane.

With a sharp knife fitted to a handle with the proper aural angle, the fold is divided midway between the short process of the malleus and the periphery of the membrane, or just immediately behind the short process. The result is the production of a more or less elliptical perforation and a return of the handle of the malleus to a nearly normal position.

The results are, however, very disappointing as a rule, the temporary improvement in audition rapidly disappearing, and the tinnitus becoming ultimately as pronounced as before operation.

Tenotomy of the Tensor Tympani Muscle. — The indications for tenotomy of the tensor tympani muscle are so ill defined, and its performance of such an experimental character that as a means of treatment it is not to be recommended. In cases of extreme retraction of the membrane, it is possible, although not certain, that the muscle is shortened, whereas it is certain that other gross intra-tympanic lesions are present, such as occlusion of the Eustachian tube, changes in the ossicular chain, and in the labyrinthine windows. Hence the division of the tendon can at the best have but a very slight effect.

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[1] *Wiener med. Wochenschrift*, 1871.

Notwithstanding the publication of occasional cases in which this procedure has been said to have done good, the writers, who have practised the operation occasionally, have come to the conclusion that division of the tendon when accomplished is followed by no improvement of any practical value.

Tenotomy of the Stapedius Muscle.—Tenotomy of the stapedius muscle, and mobilisation or extraction of the stapes have proved so useless in cases of chronic adhesive catarrh, as to have been now practically abandoned. The same remark unfortunately applies to the results obtained from excision of the membrane and larger ossicles and division of fibroid adhesions uniting the footplate of the stapes to the margins of the fenestra ovalis.

CHAPTER XVI

ACUTE SUPPURATIVE OTITIS MEDIA

Acute Suppurative Otitis Media (*Otitis media purulenta acuta*).—Acute suppurative inflammation of the mucous membrane lining the middle-ear tract may occur at any age. It is, however, most frequently met with in childhood and early adult life.

Exciting Causes.—1. The more common exciting causes are the exanthemata, especially scarlet fever and measles. Scarlet fever, when complicated with diphtheria, is peculiarly prone to attack the middle ear and to lead to great destruction of tissue, exfoliation of the ossicular chain, and involvement of the internal ear (*panotitis*). Diphtheria, typhoid fever, and smallpox are also important causative factors.

2. Epidemic influenza, bronchitis, catarrhal and lobar pneumonia, whooping-cough, cerebro-spinal meningitis, pulmonary phthisis, mumps, diabetes, and Bright's disease.

3. Catarrhal affections of the upper respiratory tract—nasal and post-nasal catarrh, pharyngitis, tonsillitis.

4. Injuries, either direct or indirect, such as a blow upon the ear, the entrance of sea water into the auditory meatus while bathing, foreign bodies in the ear, the employment of dirty sheep's wool and cotton-wool plugs, figs, fat bacon, onions, and other popular nostrums, chloroform, laudanum, etc., and more especially injury to the membrane as the result of unskilful efforts to extract foreign bodies, the application of irritants to the membrane, too forcible use and abuse of the nasal douche and Valsalva's method of inflation, and unskilful paracentesis.

5. The direct effect of cold air upon the side of the head from sitting in a draught in a railway carriage, etc.

6. Infection from suppurative disease of the nasal accessory sinuses or septic conditions of the mouth.

7. Causes such as dentition, the presence of carious teeth, sitting in damp clothes, etc.

Predisposing Causes.—The main predisposing causes are the possession of an hereditary tendency to ear disease, or to conditions provocative of ear disease, such as the presence of post-nasal adenoids, either alone or in combination with enlarged tonsils, mouth-breathing, and all varieties of nasal stenosis, the existence of a perforated membrana tympani (dry perforation), previous catarrhal or suppurative affections of the middle ear, the strumous, tubercular, or catarrhal diathesis, or the existence of some inflammatory process involving the tissues of the external auditory meatus or dermic layer of the membrana tympani.

Pathology.—It is somewhat difficult to draw a sharp line of distinction between the various types of acute inflammation of the middle ear. Such distinctions as mucous, catarrhal, serous, membranous, and purulent are arbitrary, as they often merge into one another and may merely represent stages or degrees rather than separate forms which are due to variations in the nature and intensity of the infection. A mucous catarrh may terminate as a purulent discharge.

There is, however, a distinct clinical difference between a mild catarrhal or mucous type of inflammation and one that is definitely pyogenic from the first.

In each form there is an early stage of hyperaemia with swelling of the antro-tympanic muco-periosteum, shedding of the lining epithelium and exudation of leucocytes — a point at which inflammation may cease (Fig. 103). Should the process chiefly involve the Eustachian tube and adjacent portion of the tympanum, partly owing to the presence of glands in that region, the secretion is especially mucous in character for several days, but like all the others becomes opaque and more or less purulent before clearing up.

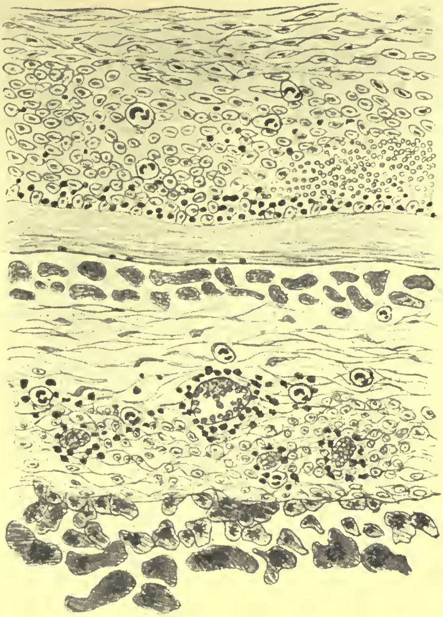


FIG. 103.—Acute suppuration of middle ear. Section of tympanic mucous membrane. Obj. ⅙ in. Lower part is the internal aspect.

Should the attack be of wider extent and of greater intensity, vascular distension and leucocytic infiltration are so increased as to still further reduce the size of the cavity and obscure its landmarks.

The process may now be of two distinct types. The exudate may consist of leucocytes, erythrocytes, and *serum*, or those cells combined with *plasma*. In the former, fluid pus with but slight coagulability escapes, while the latter, owing to its holding fibrinogen, rapidly coagulates and only becomes fluid pus with disintegration of the clot a day or two later.

The discharge in cases of acute suppuration will therefore vary in its cytological details. The most prominent feature in all stages and degrees will be the leucocyte, polymorphic and sharply defined at first, but later becoming irregular in outline, indistinct in its staining reaction, granular and pyknotic. About the third day mononuclear leucocytes will be found. Lymphocytes and epithelioid cells are very scanty at first, but tympanic epithelium will be easily recognised in primary cases at an early stage. It occurs singly or in clumps and may be spherical or pyriform in shape. The nucleus is single, round or oval, while the cytoplasm is clear and extensive. These cells soon disappear and phagocytic leucocytes become numerous. Tympanic epithelium is but rarely found except on the first day (Plate III. Fig. 2, and Plate IV. Fig. 1).

Should granulation tissue be found, lymphocytes are much more numerous. The presence of many endothelial cells is indicative of a high degree of inflammation.

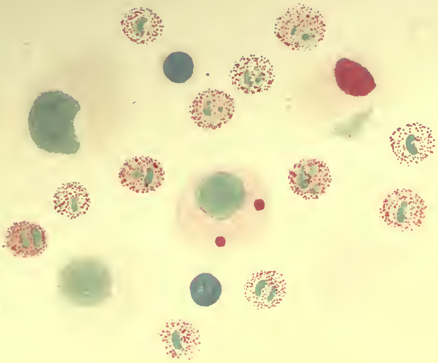
Later on all cells show granular changes in their cytoplasm, and their nuclei stain feebly and undergo pigmentation (pyknosis). Phagocytes become fewer as suppuration is prolonged. Red-blood corpuscles are as a rule only numerous in the early stages, especially in the membranous type, when they and a few drops of serum may be the sole result of paracentesis. Exudation may thus reveal three kinds of fluid:—(1) A thick, tenacious, stringy, semi-opaque, or catarrhal fluid very difficult to remove, even by suction. (2) A scanty, sanguineous, or serous exudate attending the membranous or plastic exudate. (In this type paracentesis may only yield a few drops of blood.) (3) Milky or creamy pus, more or less sanguineolent, associated with many leucocytes and multi-microbic infection, the commonest form.

It is important to bear in mind that the "membranous" type is not necessarily due to the Klebs-Loeffler bacillus, for it is often associated with the pneumococcus, diplococcus catarrhalis, and many other bacteria.

In 52 cases of primary acute suppurative otitis media the following bacteria were found. Although often present in very large numbers, intra- and extra-cellular, as compared with chronic disease, they present but few varieties:—

	Times.	
Diplococci occurred—		
Diplococcus catarrhalis	23	
Pneumococcus	9	
Meningococcus	4	
Gonococcus	3	
	—	39
Streptococcus		11
Staphylococcus		4
Bacillus coli communis		4
Bacillus proteus vulgaris		3
Acid-fast bacillus, tubercle		2
Acid-fast bacillus, pseudo-tubercle		1
Bacillus subtilis		2
Spirochaeta foetida		1

PLATE III



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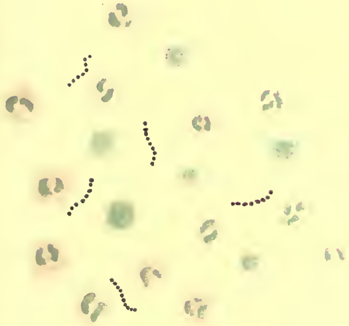

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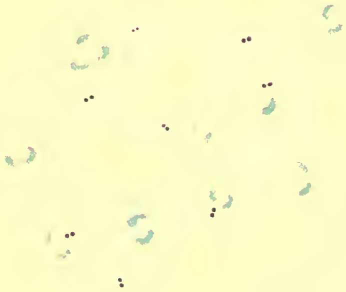

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Fig. 1.—Acute osteomyelitis of mastoid, showing myeloid cells. Obj. $\frac{1}{12}$ in.

Fig. 2.—Acute suppuration of middle ear, showing leucocytes and a few lymphocytes. Obj. $\frac{1}{12}$ in.

Fig. 3.—Acute catarrh of the middle ear (early stage), showing tympanic epithelium. Obj. $\frac{1}{12}$ in.

	Times.
Bacillus influenzae	2
Hoffmann's bacillus	1
Micrococcus tetragonus	1
Bacillus capsulatus mucosus	1
Bacillus septus (Cautley's)	1

Note.—In addition to the above the writer has recently investigated 3 cases in which the *Bacillus capsulatus mucosus* was the prevailing organism. In 2 of these there was meningitis, 1 of which proved fatal.

It will thus be seen that diplococci occurred most frequently, the large Gram – diplococcus catarrhalis being the commonest form. Notwithstanding the assertion that the bacillus septus so frequently occurs in "common cold," it was only identified in 1 case. Tubercle bacilli occurred in 2 instances, but it is reasonable to assume that the pus was due to the accompanying pyogenic bacteria.

Although all regions of the middle-ear cleft may be involved in the acute process, the greatest intensity of attack may be specially concentrated upon one part or region, *e.g.* the antrum. This is especially common in children, and if of streptococcal infection it may be the chief seat of mischief and attended or followed by acute osteomyelitis, while the tympanum itself is apparently but slightly involved.

The tympanic membrane is affected in several ways. There may be simply hyperaemia of its vessels, with change in lustre, transparency, and mobility, slight desquamation of its cuticular and tympanic coverings, or rapid leucocytic effusion and perforation. Interlamellar accumulations are common. They may give rise to clear or opaque bullae according to the nature of the fluid, or may form ecchymoses from blood extravasation between the fibrous and cuticular layers. Although the latter are often the result of traumatism, they most frequently appear in the course of an acute suppuration of the middle ear, and are of some interest by reason of their migratory properties in a downward direction from the centre to the periphery of the membrane, where they finally disappear in the course of a few weeks.

The very high degree of deafness, so often found, is readily explained by the swelling of the muco-periosteum of the *pelvis ovalis* and *fossula rotunda*, which apart from accumulation of exudate, rapidly obliterates the adjacent windows and so interferes with labyrinthine conduction. Further, the whole antro-tympanic chamber is often filled with tough coagulated lymph in which the ossicles are embedded, and by which the *ostium tubae* is temporarily sealed.

Mobility of the ossicles will further be impaired by arthritic and myositial changes, while the infective process may extend to the labyrinth, the cranial cavity, the facial canal, and the external auditory meatus.

Symptoms. — Subjective. — By far the most important subjective symptom is *pain.* At first it is confined to the depths of the auditory meatus, but rapidly radiates over the corresponding side of the head, forwards to the forehead and upper teeth, backwards towards the occiput, and downwards towards the shoulder. It is invariably more intense in children than in adults. In children, remissions of pain are frequent, whereas in adults the pain, if, perhaps, not quite so severe, is more continuous. It is aggravated by pressure around the ear, and more especially by pressure applied directly in front of the tragus and along the course of the Eustachian tube, since such acts as mastication, yawning, coughing, sneezing, or blowing the nose cause a temporary increase of discomfort. It is, as a rule, worse at night, and induces marked restlessness, especially in children. In the early hours of the morning it may subside for a time, and permit of sound sleep. As a rule, the tissues over the mastoid process are tender both to pressure and percussion, owing to the fact that in every case of acute suppuration of the middle-ear tract, the mucosa lining the mastoid antrum and frequently also the adjacent mastoid cells is inflamed if not actually septic.

In influenzal otitis media the pain is peculiarly severe, and frequently lasts for days even after rupture of the membrane has taken place.

In tuberculous otitis media, on the other hand, great destruction of tissue may take place quite painlessly. The supervention, however, of pyogenic infection, invariable in such cases, at once leads to painful swelling and oedema of the mucosa.

The peculiar neuralgic character of the pain so frequently complained of by adult patients may lead to a diagnosis of neuralgia, unless a careful objective examination of the membrana tympani be made. On the other hand, it must be noted that a genuine trigeminal neuralgia, due to a concomitant inflammation of the Gasserian ganglion, by no means infrequently complicates an acute otitis media. In addition, a peculiar throbbing pain, unrelieved by local pressure and increased by lowering the head, is frequently complained of.

Tinnitus.—Subjective sensations of a rushing, whistling, pulsating, or throbbing character are almost invariable, and are due either to the presence of acutely dilated tympanic capillaries, to pressure from exudation upon the labyrinthine windows, to muscular spasm, temporary arthritis, or to a concomitant hyperaemia of the internal ear. The presence of exudation in the cavity of the middle ear may also give rise to various crackling or bubbling noises. After perforation of the membrane has taken place tinnitus usually disappears, or is materially lessened in intensity. Its prolonged continuance, after all suppuration has ceased, is an unfavourable sign, and indicates, as a rule, ossicular adhesions, more especially stapes-anchylosis, or damage to some portion of the internal ear.

In those rare cases of intense inflammation of the tympanic cavity without perforation, the whole membrane may be seen to pulsate, giving rise to deep-seated throbbing sensations in the head.

Vertigo.—Is on the whole a comparatively rare symptom. Its persistence, after all acute inflammatory symptoms have subsided, indicates either incipient stapes-anchylosis, or some intra-labyrinthine extension. It is occasionally due to an acute carious erosion of the external semicircular canal with opacity of the peri- and endo-lymph, due to leucocytic and sometimes lymphocytic infiltration of the membranous canals.

Facial paralysis or *paresis* is not, as a rule, a common symptom in acute otitis media. When present it is due to inflammation of the facial nerve in its passage through the tympanum, owing to the presence of dehiscences in the bony covering of the aqueductus Fallopii.

Temporary disturbance of taste over the anterior two-thirds of the tongue is an occasional symptom.

Autophony is frequently present, the result of moderate exudation into the tympanum.

Impairment of hearing is at first, as a rule, slight, but later on when the cavum tympani is filled with inflammatory products it becomes very pronounced. When there is a concomitant hyperaemia of the internal ear high grades of deafness are induced.

A disagreeable taste and smell are at times complained of when an escape of pus takes place *per tubam* into the naso-pharynx.

Constitutional Disturbances.—In infants and young children the onset of an acute otitis media is ushered in by such acute symptoms as to simulate an attack of meningitis. Rigors occasionally take place in the early stages of the purulent process, whilst the temperature frequently reaches 102° to 103° F. Intense otalgia with a high temperature may mark the early stage of pneumonia owing to implication of the vagus. This is an important point in the differential diagnosis of that disease. In young children vomiting, delirium, and severe headache are frequently noted.

Objective.—The objective indications of acute purulent otitis media vary according to the stage of the disease, and for convenience of description may be divided into :—

1. Appearances before perforation of the membrane has taken place.
2. Appearances following perforation.

1. The earliest sign is an intense congestion of the peripheral vessels of the membrane, followed shortly afterwards by acute dilatation of those which run along the handle of the malleus, and later on by distension of the radial vessels which course from the handle of the malleus to the periphery, giving rise to the appearance of a wheel with red spokes.

In course of time the whole membrane becomes intensely congested, and in very severe cases quite livid. The degree of congestion may be so great as to cause visible pulsation.

In many cases a localised pulsating spot is to be noted, situated in the neighbourhood of the light reflex, or in the postero-superior segment. At this point perforation is prone to take place.

The intensity of the inflammatory process leads at times to extravasations of blood between the membrana propria and the dermic layer of the membrane, with the result that red or yellowish-red bullae make their appearance.

There is, in addition, marked loss or diminution of lustre, disappearance of the light reflex, impaired mobility, flattening or disappearance of the *processus brevis* followed by bulging of the membrane, especially in its posterior segment. Coincidental swelling of the walls of the meatus in the immediate neighbourhood of the membrane is frequently observed.

In course of time the bullae rupture and discharge their contents into the auditory meatus. In adults, and more especially amongst those who have previously suffered from suppurative otitis media, large bullae simulating mucous polypi are occasionally found upon the postero-superior segment of the membrane. They are, however, easily differentiated from polypi by careful examination with a probe. Haemorrhagic exudations are most frequently met with in cases of influenzal or diabetic origin. In primary acute attacks it is often possible to see the character of the exudation which is taking place into the cavity of the middle ear. When, however, the membrane is thickened as the result of previous catarrhal middle-ear disease and its normal translucency gone, this is not possible. As the inflammatory process increases the various landmarks become obliterated owing to swelling and oedema of the various layers of the membrane, the posterior segment becomes bulged outwards as the result of accumulation of exudation in the cavum tympani, and the outer surface of the membrana tympani presents a mottled appearance partly due to maceration and exfoliation of its superficial epithelial cells. In the immediate neighbourhood of the *annulus tympanicus* the walls of the osseous meatus appear red and slightly swollen.

The increasing pressure of the pent-up products of inflammation within the middle ear, together with their solvent action, causes the membrane to rupture at the point of least resistance, frequently over the area of an inter-lamellar abscess.

In the ordinary type of pyogenic infection of the tympanic mucosa only one perforation, as a rule, is found, but in tuberculous disease two, or even three perforations are common. In the early stages of the disease the perforation is fairly circular, with clean-cut vascular edges. As chronicity becomes established it tends to enlarge and to assume various shapes, *e.g.* reniform, horse-shoe shaped, etc.

Appearances following Perforation.—The size, shape, and situation of the perforation vary within wide limits. It may be quite minute or may occupy the greater portion of both segments of the membrane, or may be situated in the *membrana flaccida*. The membrane surrounding it is swollen and congested, while the normal landmarks are either indistinct or entirely obliterated. When minute its situation may only be visible by the appearance of a bright glistening and pulsating reflex from the distended tympanic capillaries. When there is interference with free drainage it may be seen at the apex of a nipple-shaped projection.

In exanthematous cases there is often almost complete destruction of the membrane. The perforation may be circular, oval, elliptical, or reniform. The tympanic mucosa as seen through the perforation presents in acute cases a bright red and congested appearance, while the amount and character of the discharge varies with the intensity of the inflammatory process.

Prognosis.—The prognosis of acute purulent middle-ear disease is influenced by various general and local considerations. When occurring in an otherwise healthy subject living under favourable external conditions, and especially if the affection is primary and due to some such accidental cause as naso-pharyngeal catarrh, sea-bathing, etc., the prognosis is good. The earlier that rupture of the membrane takes place, and the more rapid the cessation of pain, tinnitus, and discharge, the better the ultimate result. The absence of any symptoms indicative of mastoid or labyrinthine involvement is also favourable.

The persistence of marked swelling of the membrane, the presence of a small perforation insufficient to efficiently drain the cavity of the middle ear, involvement of mastoid cells, enlargement of peri-auricular glands, exfoliation of ossicles, and facial paralysis are all factors which render the prognosis much less favourable. In tuberculous, syphilitic, and diabetic patients the prognosis is unfavourable.

Cases due to measles, scarlet fever, diphtheria, scarlatinal diphtheria, typhoid fever, and epidemic influenza are less favourable partly on account of the liability to greater destruction of tissue and partly to the greater frequency of mastoid and labyrinthine involvement.

Treatment.—1. Before rupture has taken place.—The main indications are to relieve pain and to afford free exit for the products of suppuration.

If possible, the patient should be confined to bed in a warm and slightly darkened room. A smart purge, preferably an alkaline aperient, should be administered, and all food should be light and capable of easy digestion. To diminish arterial or general blood-pressure, calomel, antimony or aconite may be administered, or heat applied to the feet or abdomen. To secure rest and sleep a subcutaneous injection of morphia is advisable.

To relieve pain the application of heat is always grateful. It should be applied in the form of dry heat, *e.g.* gauze and wool pads, or Leiter's coil with hot water. The use of poultices should be entirely discarded, tending as they do to further infection and to exaggerate the hyperaemia, to maceration of the skin, and to the production of tympanic granulation tissue. In exceptional cases cold may be better borne than heat. It may be applied in the form of an ice-bag round the ear or Leiter's coil may be utilised. Very marked relief is obtained from the application of leeches. From two to six leeches, the number varying with the age of the patient and the intensity of the inflammatory process, should be disposed around the ear, especially in the neighbourhood of the tragus, and allowed to draw blood until they fall off. The haemorrhage may be further encouraged by the application of hot sponges, hot pads of spongiopiline, Bier's cup, etc. The local abstraction of blood thus effected gives great relief to the existing pain and tends materially to shorten the inflammatory process. When ordinary leeches are not available the artificial leech (Heurteloup) will be found of service.

The instillation into and the retention in the meatus of warm sterilised water, or medicaments such as solutions of cocaine, cocaine and adrenalin, glycerine of carbolic acid (B. Hewetson), acetate of aluminium or of lead, etc., is useful.

The inhalation of medicated vapours such as the compound tincture of benzoin, benzoin and chloroform, pine oil, menthol and camphor, conium, in cases complicated with nasal or naso-pharyngeal catarrh is beneficial.

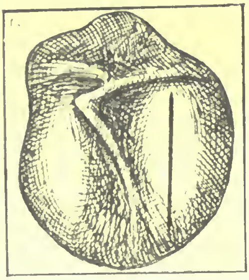

Fig. 104.—Acute suppurative inflammation of middle ear. Line of incision through the most bulging portion of the posterior segment for drainage purposes.

Spraying the nasal, and more especially the naso-pharyngeal mucosa, with warm alkaline antiseptic lotions should never be neglected. On no account, however, should forcible nasal lavage or the nasal douche be employed.

When the membrane is highly congested and swollen and when there is the least sign of flattening or bulging, no time should be lost in freely incising it (Fig. 104). In order to anaesthetise the membrana tympani prior to its incision the meatus should be filled with a 5 per cent solution of cocaine (alkaloid) in aniline oil. Strict antiseptic precautions should be adopted in making the incision for fear of converting what may be a mild infection into a virulent one as the result of external contamination. When a yellowish coloration, indicative of the presence of pus within the middle ear, is seen, immediate incision is called for. To be effective the incision should be made through the bulging portion of the membrane, and of such a length as to afford an opening sufficiently large to freely drain the cavity of the middle ear. A crescentic, vertical, or horizontal incision may be made according to the fancy and skill of the operator. The writer much prefers the horizontal incision from the fact that it is not liable to heal up quite so quickly as either a crescentic or vertical one. Incision of the membrane under such circumstances not only materially lessens the existing pain, but has also the effect of tending to avert permanent damage to the tympanic contents and of diminishing the chances of extension of disease to the cellular spaces of the mastoid process and intracranial structures. Incision may not, however, immediately reveal the presence of pus in the tympanum, owing to the exudate being of the plastic or membranous type. Within about twenty-four

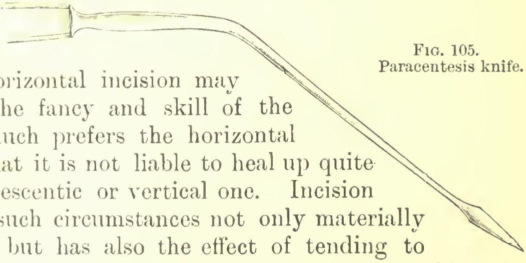

Fig. 105. Paracentesis knife.

hours there is, as a rule, a free, purulent discharge. Practical difficulties are frequently encountered in maintaining the patency of such an incision, and despite all attempts it may heal before resolution of inflammation within the middle-ear tract has taken place, and require re-incision. Puncturing the membrane with a fine galvano-cautery point is, in special cases, a most useful method of maintaining a free opening. Under such circumstances frequent instillations of warm sterilised water, 2 per cent aqueous solutions of boracic acid, or 6 per cent solutions of slightly-warmed peroxide of hydrogen lotion will be found useful in promoting a free discharge.

When, after incision of the membrane, pain continues, as is frequently the case in influenzal otitis media, the instillation of warm sterile solutions of muriate of cocaine (5 to 10 per cent), of morphine, or cocaine and atropine solution (2 to 4 per cent), will be found to act beneficially.

In quite exceptional cases relief from pain is only secured after irrigation of the middle-ear tract *per tubam* with warm sterilised normal salt solution.

Following incision of the membrane, aspiration of the contents of the tympanum is advisable. Suction by means of Sondermann's apparatus or Siegle's pneumatic speculum (Fig. 23) should be performed and continued until there is a free flow of discharge from the middle ear. Aspiration has the threefold advantage of relieving the existing pain, of everting the edges of the incision and thus preventing their too early union, and of bathing the infected mucosa with serum drawn from the dilated tympanic blood-vessels.

Bier's Method of induced Hyperaemia.—In 1903 Professor Bier[1] published a paper upon the effects of induced hyperaemia in the treatment of acute inflammatory and suppurative conditions, urging that by its employment successful results were frequently obtained and operative interference rendered unnecessary. Of 18 cases of otitis media subjected to treatment by induced hyperaemia 12 were cured at once, the remaining 6 requiring operation.

In 1905 Heine[2] and Keppler[3] published their experiences in the treatment of 19 and 21 cases respectively.

The results in Heine's cases (in 4 both ears were affected) were that in 7 out of 15 cases a cure was obtained without operative interference other than an incision of the membrane, the cure being complete in from six to ten days. In Keppler's series, 11 of which were cases of acute otitis media with mastoid involvement, complete cure resulted without resort to antrectomy in from two to four weeks.

The technique adopted is as follows:—An incision through the swollen and bulging membrane is first made, the patient is then put to bed and a slightly elastic rubber bandage 1½ in. in width is applied round the neck. In children it is sufficient if the bandage be one half-inch in width. The bandage is drawn sufficiently tight to induce slight cyanosis of the face, but not so tight as to cause pain in the inflamed area. It is retained in position for twenty-two hours at a time, and after an interval of two hours is again replaced.

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[1] *Die Hyperämia als Heilmittel*, Leipsic, 1903.

[2] *Verhand. der Deutschen Otologischen Gesellschaft*, June 1905.

[3] *Zeitschrift für Ohrenheilk.* Bd. 50.

The almost immediate effect of the employment of induced hyperaemia is to relieve pain.

In the event of a co-existing sub-periosteal mastoid abscess an incision should be made so as to afford egress to its purulent contents; otherwise pain will be increased.

Induced hyperaemia should not be employed in patients suffering from arterio-sclerosis, cardiac or renal disease, or in cases where immediate professional superintendence is not available, the main drawback to its employment being that unless the treatment be very carefully supervised the psychological moment for surgical interference, should this be necessary, may be missed. In other words, treatment by means of Bier's method tends to somewhat mask the acute symptoms of the disease and to convert the manifest into the latent.

In the event of the discharge from the middle ear neither diminishing nor losing its purulent characteristics within forty-eight hours—even if the mastoid tenderness be less—operative interference is indicated. Again, if the temperature should fall only to rise again, or if from the first it steadily rises, operation should not be delayed.

If treatment by induced hyperaemia be used at a sufficiently early stage of the acute attack the chances are in favour of a rapid resolution of the inflammatory process and of an early re-establishment of the auditory function. In the experience of the writers, Bier's induced hyperaemia has very narrow limitations. It should never be regarded as a substitute for incision, but merely as a supplementary method of treatment. Its employment in acute cases, where there is always a risk of intra-cranial infection, is treacherous, and is attended by considerable risk. If employed at all the patient should be most carefully watched in case of grave symptoms suddenly making their appearance.

After perforation has taken place the indications are to maintain efficient drainage until purulency has been arrested, to employ such remedies as are most likely to bring the infective process to an end, and to endeavour to prevent intra-tympanic adhesions.

Small perforations should invariably, and upon general surgical principles, be enlarged. In very many cases the existing perforation will be found inadequate, and were free incision a more frequent and routine method of practice much chronic disease and many severe complications would be averted. When the discharge is scanty, and when there is no barrier to its free exit, one or other method of dry treatment may be adopted. After careful disinfection of the meatus with a warm solution of carbolic acid, izal, or bichloride of mercury, the parts should be thoroughly dried with absorbent wool and powdered boracic acid (Bezold), iodoform and boracic acid (1-4), aristol, dermatol, or europhen powder lightly insufflated so as to completely cover the perforation. Every day, or every second or third day, according to the amount of discharge, the meatus is cleansed and a fresh supply of powder insufflated.

Treatment by means of packing is equally useful in cases where suppuration is not profuse, where there is a large perforation, where there is no secondary inflammation of the meatal walls, and where, from the habits and surroundings of the patient, it is desirable that the ear should not be interfered with. A narrow strip of iodoform or double cyanide gauze is introduced and carefully carried down to the membrane with a pair of angular forceps. The meatus is then lightly filled up and the packing left *in situ* for a few days. It should be changed as frequently as it becomes soaked with discharge. When gauze tampons cause superficial inflammation of the meatal walls wicks of sterilised absorbent wool may be substituted.

Treatment by means of syringing and the instillation of fluid medicaments should be carried out in all cases where discharge is profuse, and where the dry method of treatment is inapplicable. The meatus is first of all thoroughly syringed with warm sterilised water or an alkaline antiseptic lotion, and then dried with absorbent wool.

The particular lotion to be employed is warmed and poured into the auditory meatus, the patient lying with the affected ear uppermost. The lotion should be allowed to remain in contact with the inflamed membrane for at least ten minutes at a time, and its absorption into the cavity of the middle ear assisted by the frequent performance of a negative Valsalva.

In acute cases soothing alkaline antiseptic lotions are better borne than astringent and caustic preparations. Astringent preparations should be employed only in those cases where such remedies as boracic acid, hydrogen peroxide, glycerine of carbolic acid, etc., have been found unavailing.

Irrigation of the middle ear *per tubam* is frequently very beneficial, especially when pain and free discharge persist after careful treatment through the meatus. Before employing this method, care should be taken to see that the existing perforation is of sufficient size to permit of a free escape of the injected fluid.

Whether inflation of the middle ear by means of Politzer's bag, or the Eustachian catheter should be employed in the early stages of an acute suppurative otitis media is still a moot point. The experiments of Young and Milligan[1] go to prove that inflation of the middle ear when the perforation of the membrane is small is inadvisable and should not be practised, on account of the almost certain risk of driving infective secretion towards the posterior end of the middle-ear cleft and into communicating mastoid cells.

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[1] *Journal of Laryngology*, September 1905.

Schultz[1] has confirmed these observations, using methylene blue and blue-stained glycerine for injection into the middle ear. When a small perforation was present the coloured fluid was forced by catheterisation into the mastoid cells. When, on the other hand, the perforation was large, the cells of the mastoid process remained free, and the coloured fluid escaped by the auditory canal.

Politzer,[2] on the other hand, regards the abandonment of the air douche in such cases as a retrograde step, his experience leading him to believe that those cases treated with frequent air inflations heal much more rapidly than those not so treated.

According to the observations of Lermoyez, Lubet-Barbon, and Moure,[3] "the air douche by Politerisation cannot provoke mastoiditis, because as there cannot be otitis without antritis the air-bulb cannot create what already exists."

The experience of the authors, both from experimental and clinical observations, is against the performance of inflation in acute cases, unless the perforation of the membrane is so large as to quite preclude the possibility of secretion being driven beyond it. The general principle of keeping an acutely inflamed organ as far as possible in a state of physiological rest should be adhered to.

Terminations.—Acute purulent middle-ear disease may terminate in—

1. Complete cure with cicatrisation of the perforation and restoration of hearing power.

2. Cicatrisation of the membrane with the continuance of a seromucous discharge within the *cavum tympani.*

3. Cicatrisation of the membrane with adhesion to the inner tympanic wall, with intra-ossicular adhesions, or adhesion of the foot-plate of the stapes to the margins of the *fossula ovalis.*

4. Extensive destruction of the membrane with or without exfoliation of the *ossicula auditus*, and with a resulting high grade of deafness.

5. In paresis of the intra-tympanic muscles.

6. In chronic suppurative disease.

Complications.—1. Extension to adjacent mastoid cells and production of an acute mastoid empyema. In the acute otitis media of influenzal origin extension to the mastoid cells with the formation of a subcortical apical mastoid abscess is peculiarly prone to take place.

2. Extension to the internal ear, either by erosion of some portion of the external labyrinthine wall, *e.g.* external semicircular canal, or by the direct passage of infective organisms through the labyrinthine windows, or obliteration of the fossula rotunda from cicatricial contraction of the tympanic muco-periosteum, and temporary deafness from the lodgment of inspissated pus in it.

3. In the production of such intra-cranial complications as meningitis, cerebral or cerebellar abscess, perisinusal abscess, lateral sinus

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[1] *Inaug. Dissertation*, Bern, 1905.

[2] *Diseases of the Ear*, 1902.

[3] *Annals of Otology*, December 1904, vol. xiii. No. 4, p. 648 *et seq.*

thrombosis, or extra-dural abscess. With the exception of extra-dural abscess, these complications are more frequently met with as the result of acute exacerbation of chronic infective disease of the middle ear with osseous lesions. Extra-dural abscess is, however, a frequent complication of acute otitis media (p. 372), especially when of pneumococcal origin.

4. Septicaemia or pyaemia.

CHAPTER XVII

EPITYMPANIC SUPPURATION WITH PERFORATION OF THE MEMBRANA FLACCIDA SHRAPNELLI

Epitympanic Suppuration with Perforation of the Membrana Flaccida Shrapnelli.—Disease of the recessus epitympanicus or "attic" of the middle ear is one of the most troublesome and obstinate forms of suppuration affecting the middle-ear cleft. According to the writer's observations it occurs in about 3 per cent of cases of suppurative middle-ear disease.

The epitympanic cavity, about 6 mm. in height, is situated above the level of the short process of the malleus. Its outer wall is formed by the inner end of the superior osseous wall of the meatus, the *margo tympanicus*, and by the *membrana flaccida*. It contains the head and neck of the malleus, the body of the incus, the stapes and their ligamentous attachments. The relative position of the ossicular chain and its ligaments is such as to divide the cavity into two compartments, an inner, which is the larger, and an outer, which is considerably smaller. The outer attic is further subdivided into two spaces, an upper and a lower (Fig. 93). The upper, which is bounded above by the superior ligament of the malleus and below by its external ligament, is subdivided by reduplications of mucous membrane into a varying number of small compartments, any or all of which may be the site of suppurative disease.

The lower or Prussak's space, is bounded above by the external ligament of the malleus, and externally by the *membrana flaccida*. Owing to the anatomical arrangement of the various ligaments and reduplications of mucous membrane, suppuration in this region is peculiarly intractable on account of the difficulties encountered in securing free drainage and ingress for medicaments, and also on account of the peculiar liability to parietal and ossicular caries.

Epitympanic suppuration may be part of a general infection of the middle-ear tract, more especially of its posterior or antral end, or it may be a strictly localised process due to extension of inflammation along the walls of the auditory meatus. It also frequently occurs as the result of long-continued Eustachian obstruction with infection. In many cases of diffuse infection of the middle-ear cleft the epitympanum becomes shut off from the tympanum proper by the formation of inflammatory adhesions. In such cases the lower segment of the membrana tympani is found markedly indrawn, and the processus brevis unduly prominent, while the upper segment may be unduly prominent before perforation takes place. Inflation by means of Valsalva's method or the air douche, whilst causing a slight bulging of the retracted and frequently adherent membrane, produces no effect upon secretion lodged in the epitympanum.

Perforation of the membrana flaccida is not uncommonly associated with defects in the membrana tympani, more especially with perforation of its posterior segment.

"Attic" perforations are often difficult to see on account of their minute size and the frequency with which they are concealed by tufts of granulation tissue, inspissated secretion, and epithelial debris. Perforation of the anterior portion of the membrana flaccida is frequently associated with chronic Eustachian obstruction due to nasal or post-nasal causes, while central perforations are held by various authorities to be sometimes due to extension of disease along the meatal walls, and are frequently associated with caries of the margo tympanicus and head of the malleus, whilst perforations situated in the posterior segment are commonly associated with antral suppuration.

Epitympanic suppuration is peculiarly prone to be associated with cholesteatomatous formations, imperfect drainage, and with Eustachian obstruction. The size of the perforation varies greatly. It may be no larger than the head of a pin, or it may occupy the whole of the membrana flaccida. It is most frequently found immediately above the short process of the malleus, and is of a circular shape with a congested periphery. The appearance of the pars tensa is at times perfectly normal, at other times it has a grey lustreless colour or is adherent to the inner wall of the middle ear.

Suppuration confined to the external attic only or Prussak's space is by no means uncommon, and is readily amenable to treatment. The minute perforation which leads into the suppurating *cul-de-sac* is frequently surmounted by a tuft of vascular granulation tissue sprouting from its mucosa, or is associated with caries of the neck or head of the malleus.

Diffuse epitympanic suppuration is, on the other hand, extremely obstinate, is usually associated with perforation of the posterior portion of the membrana flaccida, and at times with large defects in the membrana tensa, the infected cavities being either completely or partially shut off from one another by inflammatory adhesions. Tufts of granulation tissue sprouting through the perforated membrane are exceedingly common, and are generally associated with caries of the ossicular chain or annulus tympanicus. At times they attain such a size as to almost completely occlude the meatus, and render examination of the membrane impossible until after their removal.

In cases of protracted epitympanic suppuration there is almost invariably a simultaneous infection of its osseous walls, more especially the outer attic wall, the antro-tympanic roof, the head and body of the malleus, or the incus. It is by no means uncommon to find destruction of the outer attic wall, with a consequent exposure of a part or the whole of the epitympanic recess, and even of the cavity of the mastoid antrum.

Symptoms.—Acute epitympanic suppuration is attended in all cases by severe local and general symptoms, especially in young children, where the constitutional disturbance may be so great as to suggest incipient meningitis.

In adults, vertigo is not uncommon, whilst tinnitus, hemicrania, and a sense of fulness in the head are frequently complained of. The sense of hearing is frequently only slightly affected, especially in cases of suppuration of the outer attic.

Local objective indications are the presence of an intensely congested and swollen *membrana flaccida*, with redness and oedema of the meatal walls in its immediate vicinity, occasional pulsation, and the rapid appearance of a perforation.

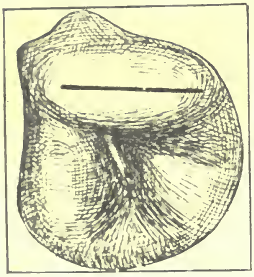


FIG. 106.—Acute suppurative inflammation of the recessus epitympanicus. Line of incision for drainage purposes.

In chronic epitympanic suppuration there are frequently no symptoms beyond the presence of a scanty, and usually slightly blood-stained and foetid discharge. Intercurrent infection is prone to produce a varying degree of pain and vertigo. The degree of deafness varies. In those cases where the suppurative process is restricted to the outer attic the amount of deafness is hardly noticeable; in diffuse suppuration of the attic, however, especially when associated with infection of the tympanum proper, deafness may be profound. This functional test is considered by Politzer to be of great value in differentiating a localised from a general attic infection.

When epitympanic suppuration is complicated by the presence of a cholesteatoma, attacks of severe pain are by no means infrequent, and are due either to infection and suppuration around the infected epithelial mass or to retention of secretion, either of which may be due to injudicious syringing.

Treatment.—In acute cases free incision of the swollen and congested membrana flaccida should at once be undertaken, followed by energetic antiseptic treatment (Fig. 106). In addition, the application of leeches round the ear is often useful. Should suppuration continue, and evidence of retention of secretion be manifest, the infected attic should be cleansed by means of an intra-tympanic cannula, and injections made with a specially constructed syringe. Tufts of granulation tissue should at once be destroyed by the application of chemical caustics or removed by forceps (Hartmann) or sharp spoons (Politzer).

The efficient treatment of chronic epitympanic suppuration is much hampered by the difficulties encountered in securing free drainage, and by the frequent co-existence of caries and cholesteatomatous collections. Exuberant granulations should invariably be removed, and small perforations freely enlarged.

To effectively cleanse the epitympanum a special cannula (Hartmann, Milligan) is essential. With the author's cannula (Fig. 107) a continuous flow of fluid at any desired pressure is obtained, whilst the effect may be watched by direct inspection.

For cleansing purposes solutions of boracic acid (gr. x. to ℥i.), bichloride of mercury ($\frac{1}{2}$ to 1 per cent), lysol, or formalin are useful, while in order to soften and to remove inspissated accumulations solutions of bicarbonate, biborate, or sulphate of sodium may advantageously be employed. The appearance in the washings of minute flakes of epidermis or of gritty particles should suggest the presence either of a cholesteatoma or of bone disease, and should be followed up by a careful microscopic examination. After thorough irrigation and sterilisation the infected cavity should be carefully dried, either by means of a cotton-tipped probe or by the inflation of hot air, and intra-tympanic injections of a few drops of hydrogen peroxide, boracic acid, or bichloride of mercury made with a fine syringe.

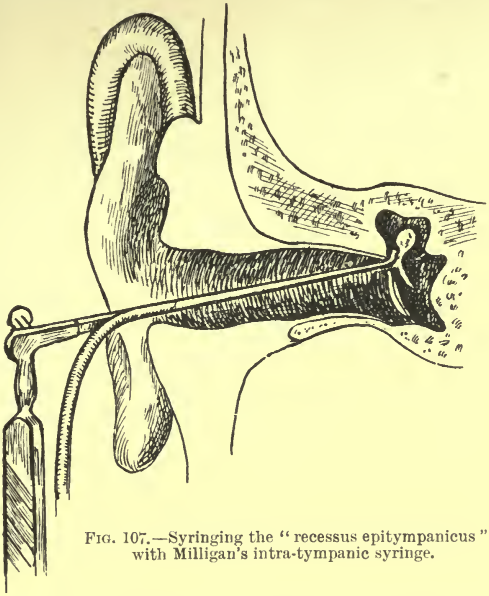


FIG. 107.—Syringing the "recessus epitympanicus" with Milligan's intra-tympanic syringe.

The insufflation of finely triturated boracic acid, iodol, airol, or ectogan powder is highly spoken of by certain writers. In the author's hands insufflations have proved practically valueless. A more efficient method, applicable, however, only where a considerable defect in Shrapnell's membrane exists, is packing the epitympanic space with a small wick of iodoform wool. To dissolve accumulations of epidermal squames or cholesteatomatous masses a solution of salicylic acid in alcohol (1 per cent) or in biborate of sodium is useful.

The frequent association of caries of the margo tympanicus and ossicular chain with epitympanic suppuration adds very materially to the difficulties of successful treatment. In those cases where the former lesion is demonstrable with the aid of a suitable probe, it is advisable to at once remove the outer attic wall by means of a sharp chisel or forceps-chisel.

To effect this the patient should be anaesthetised, and preferably in the upright position, the head being firmly held by an assistant. Under efficient illumination the soft and carious outer attic wall may be scraped away, the movements of the spoon being directed from behind forwards, sufficient bone being gradually removed to permit of free access to the epitympanum, or by means of a long and delicately constructed chisel the bony wall may be removed piecemeal, great care being taken to avoid injury to the aqueductus Fallopii.

The combined difficulties of efficiently illuminating the field and of manipulating the sharp spoon or long chisel in a meatus, frequently narrow and tortuous, make it advisable in the majority of cases to detach the auricle and to draw the cartilaginous meatus forwards from its posterior attachments. This course is more especially called for when working with the forceps-chisel.

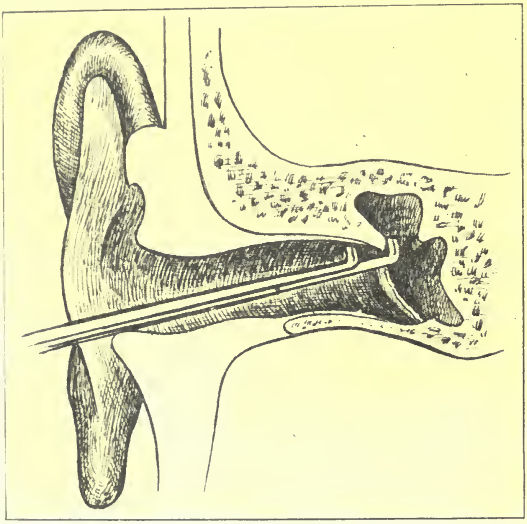


FIG. 108.—Removal of outer attic wall (semi-diagrammatic) with attic forceps.

This instrument (Fig. 109) is useful in those cases where such a considerable defect in Shrapnell's membrane exists as to permit of the easy introduction of its hook-shaped extremity into the epitympanum. Once the instrument is in position its handles are forcibly pressed together with the result that its cutting edge is propelled against the bony attic wall, which is gradually bitten away piecemeal.

Haemorrhage interfering with a view of the field of operation is best controlled by mopping with small pieces of lint soaked in adrenalin solution (1 to 1000), or by frequent irrigation with hot sterilised water.

Caries of the ossicula auditus, so frequent in cases of attic suppuration, calls for their excision.

Formerly, considerable reliance was placed upon the value of ossiculectomy as a means not only of removing disease, but also of opening up the infected area and so securing free drainage. Experience shows, however, that although the operation frequently affords temporary relief it is seldom curative, from the fact that the posterior end of the middle-ear cleft (the mastoid antrum) is invariably affected in chronic epitympanic suppuration; in fact it is frequently quite impossible to say beforehand to what extent temporal bone necrosis is associated with limited lesions of the ossicula auditus. In 32 per cent of a series of cases in which the writer performed ossiculectomy for the relief of chronic epitympanic suppuration, recurrences took place at intervals of from four months to two years, necessitating the performance of a more radical operation. That ossiculectomy, however, facilitates drainage, permits at times of the extrusion of cholesteatomata, and so relieves urgent symptoms, is beyond doubt.

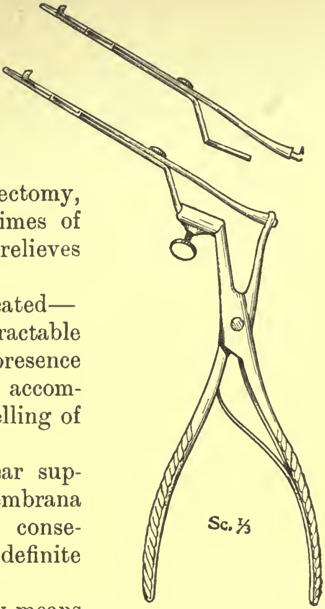


Fig. 109.—Pfau's attic punch forceps.

Ossiculectomy.—Ossiculectomy is indicated—

1. In cases of long-continued and intractable attic suppuration, with or without the presence of ossicular caries, more especially when accompanied by recurring attacks of pain or swelling of the meatal walls.

2. In those cases of chronic middle-ear suppuration where the greater part of the membrana tensa has been destroyed, and when, consequently, the malleus and incus subserve no definite function.

3. Where it can be definitely shown by means of palpation with a probe that one or both ossicles are carious.

4. Where syringing of the epitympanum demonstrates the presence of a cholesteatoma (acid-fast squames in the washings).

5. In cases of chronic suppuration of Prussak's space, attended by marked loss of hearing, where ordinary methods of treatment have failed.

6. In cases of constantly recurring granulation-polypi growing either from the head or neck of the malleus, the outer attic wall, or depths of the epitympanum.

7. In cases of extensive adhesion of the membrana tympani and handle of the malleus to the pars promontoria as the result of previous suppurative disease.

8. In cases of intractable foetid middle-ear suppuration accompanied by marked loss of hearing, in the hope of being able to avoid the performance of a radical mastoid operation.

Ossiculectomy originally proposed by Schwartze (1873) may be performed either by the per-meatal or post-aural routes.

The former is indicated where disease is localised to the ossicular chain, and where the meatus is large and roomy. It is contra-indicated in those cases when there exist, in addition to ossicular caries, disease of the antro-tympanic parietes, involvement of the mastoid antrum, the cancellous spaces of the mastoid process, and the neighbourhood of the sinus posterius; also in those cases where the meatus is stenosed as the result of inflammatory thickening of its cutaneous or periosteal lining, or a good view of the contents of the tympanum is impossible owing to the existence of undue prominence, physiological or pathological, of the meatal walls.

It may be performed with the patient sitting upright, or lying prone, and under local or general anaesthesia. After thorough disinfection of the auricle and meatus the patient is placed under the influence of a general anaesthetic, preferably chloroform, or has the field of operation anaesthetised with cocaine-aniline solution, or by deep infiltration (Neumann, Schleich). After thorough drying of the parts, as large a speculum as the meatus will admit is introduced, and the field of operation illuminated by means of a strong head-light. An incision is now made around the periphery of the membrane with a sharp-pointed knife, commencing from the free edge of the perforated membrana Shrapnelli. The membrane is in this way entirely separated from its attachment to the margins of the annulus tympanicus. The anterior, posterior, and superior ligaments of the malleus are divided by means of a sharp-pointed sickle-shaped bistoury, and the tendon of the tensor tympani muscle cut through. The malleus, now freed from its attachment, is grasped with a forceps (Politzer's), or threaded into the loop of a snare, and pulled gently downwards from the attic, and then outwards.

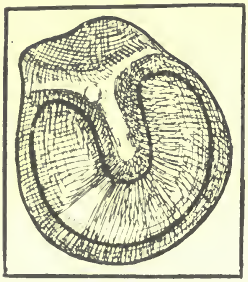


FIG. 110.—Incision for removal of the membrana tympani.

Its removal may also be accomplished by means of Delstanche's "extracteur du marteau" (Fig. 111).

With an upward and outward movement the tendon of the tensor tympani and the suspensory ligaments of the malleus are cut through, and the ossicle, already engaged in the ring-shaped instrument, is removed by gentle traction.

The anatomical position of the incus renders its removal a matter of much greater difficulty, whilst considerable skill is required to avoid injury to adjacent structures, *e.g.* the facial nerve, the outer labyrinthine wall, etc. The chorda tympani nerve is, however, invariably and permanently injured during extraction of either the malleus or incus.

In many chronic cases the long process of the incus, and even the entire ossicle, will be found to have disappeared, its ligamentous attachments having become disintegrated by constant immersion in a bath of infected pus. In addition, the incus, from the fact that it receives only one blood supply and that from the tympanic blood-vessels, is more prone to cario-necrosis than either the malleus or the stapes. Experience proves, also, that extraction of the malleus alone is rarely sufficient. Further, the fact that after removal of the malleus the function of the incus is gone is an argument in favour of the simultaneous removal of both ossicles.

Extraction of the incus may be accomplished according to the methods proposed by Ludewig or Zeroni.

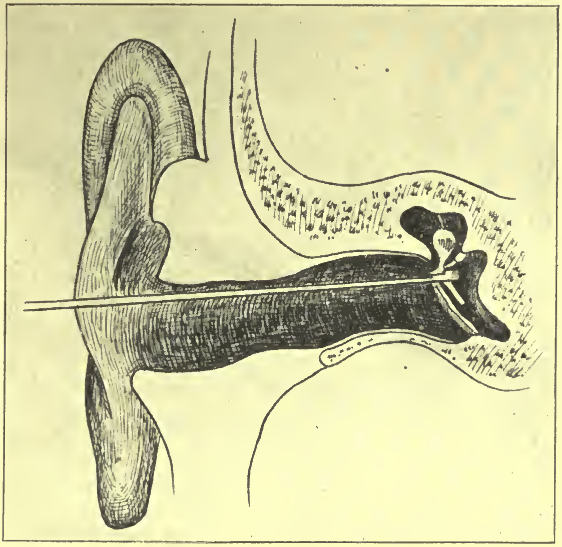


Fig. 111.—Removal of the malleus with Delstanche's "extracteur du marteau" (semi-diagrammatic).

Ludewig's Operation.—With a specially constructed right-angled knife the incudo-stapedial articulation is first divided. An incus hook (Fig. 112), with its point facing upwards (Ludewig, Kretschmann) is now introduced into the attic, when, with a downward and backward sweeping movement, the ossicle is engaged and drawn into the tympanum, after which it may be removed by syringing, or with a pair of forceps.

Occasionally the ossicle may become dislocated upwards and backwards, and, consequently, wedged into the *iter ad antrum* or posterior part of the tympanum. In either case its removal is now a matter of great difficulty, and may call for the performance of a post-aural operation.

Zeroni's Operation.—The incudo-stapedial articulation is divided as described above. The incus is then removed by means of Zeroni's hook

(Fig. 113), which is introduced into the tympanum and slid gently upwards and backwards along its inner wall, after which it is turned, with an outward movement, so as to engage the ossicle, which is in this way caught and drawn into the meatus.

The post-aural route is indicated when, in addition to ossicular caries, demonstrable evidence of caries of the outer attic wall and cholesteatomatous formations in the attic exist. Its applicability is, however, much limited from the fact that it is just in those cases that deeply-situated disease is usually encountered and whose removal necessitates a more complete exposure of the accessory cavities of the middle ear. By its performance, however, it is possible to obtain a more thorough view of the interior of the epitympanum. A curved incision is made parallel to and ¼ inch behind the attachment of the auricle. The auricle is then drawn forwards so as to completely expose the posterior bony margin of the meatus. With a raspatory the cartilaginous meatus is separated from its posterior attachments, and auricle and meatus lifted outwards and forwards on to the cheek. An excellent view of the membrana tympani and outer attic wall is thus obtained. The extent of interference now depends upon the amount and situation of ascertainable disease.

FIG. 112.—Ludewig's hook.

Following the removal of the malleus, incus, and outer attic wall, curettage of granulation tissue should be performed with an attic curette (Lake), and the mucosa swabbed with pure carbolic acid, after which the meatus is lightly packed with antiseptic gauze, and an ordinary dressing applied.

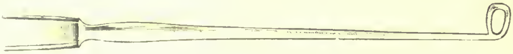


FIG. 113.—Zeroni's hook.

Extraction of the stapes is rarely called for in cases of purulent middle-ear disease, partly because this ossicle, from the fact that it is richly supplied with blood from both tympanic and labyrinthine blood-vessels, is not nearly so prone to carious disintegration as are the malleus and incus, and also because its extraction is always attended by the risk of secondary septic invasion of the vestibule.

The writer can recall but 4 cases in which he has designedly removed the stapes in uncomplicated post-suppurative middle-ear catarrh. In 3 of these cases the hearing was made distinctly worse, in 1 appreciably better. The risk of infection spreading to the labyrinth, and consequently of permanently damaging the membranous vestibule, is so great that the operation in uncomplicated purulent otitis media should only be undertaken in quite exceptional cases, and at all times with the most rigid antiseptic precautions.

CHAPTER XVIII

CHRONIC SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR

Chronic Suppurative Inflammation of the Middle Ear. — Chronic purulent disease of the mucous membrane lining the middle-ear tract is one of the most important of the morbid conditions of the ear, not only on account of the damage inflicted upon the delicate mechanism of audition, but also on account of the serious intra-cranial complications which its presence may induce, and the various systemic lesions which may follow in its train. It is in almost all cases the result of a previous attack of acute suppurative inflammation. Hence those causes which are responsible for the production of acute pyogenic inflammation of the middle ear are in turn responsible for the incidence of chronic disease.

In many chronic cases serious and often irreparable damage is limited to the membrana tympani and the ossicula auditus, whilst in others the infective process may extend outwards to the auditory meatus and auricle, backwards towards the cancellous spaces of the mastoid process, and inwards towards the labyrinth and adjacent intra-cranial structures. Certain local and general conditions predispose to chronicity, such as the existence of a perforation too small to allow of efficient drainage and ventilation, the presence of tufts of exuberant granulation tissue and intra-tympanic adhesions, which, by mechanically interfering with the exit of discharge, induce secondary and often chronic changes in the mucosa and bone, while tuberculosis, rickets, etc., may exercise constitutional influences.

The exact moment at which an acute process passes into what is usually accepted as chronic disease is impossible to define, and depends not so much upon the lapse of time as upon the progress of certain organic changes, and upon the failure of therapeutic or surgical remedies to arrest the disease in its acute phase. General conditions such as the exanthemata, measles, scarlet fever, and scarlatinal diphtheria, owing to the extensive destruction of tissue which they induce, and the strumous, tuberculous, and syphilitic dyscrasiae, predispose to chronicity. Severe anaemia and the occurrence of typhoid fever have much the same, if perhaps not so great an effect.

Other general diseases, such as epidemic influenza, pneumonia, mumps, pulmonary and laryngeal phthisis, Bright's disease, glycosuria, and the various catarrhal affections of the upper respiratory tract play an almost equally important rôle in this connection.

The condition of the nasal, naso-pharyngeal, and oral mucosa has also a very definite relation to the origin and maintenance of chronicity. Post-nasal growths, more especially post-nasal adenoids, and acute or chronic tonsillar affections by inducing recurring attacks of catarrh, thereby interfering with the normal patency of the Eustachian tubes, and septic disease of the nasal accessory sinuses are also factors of great importance. Other causes of chronicity are disregard of oral and nasal cleanliness, want of attention to the scalp, imperfect treatment of the primary acute attack, the indifference of patients so soon as pain has passed away even although discharge persists, the popular belief that a discharge is an advantage rather than otherwise, and that, if arrested, serious consequences will result, and the frequent anatomical peculiarities of the middle ear.

Certain external causes, *e.g.* injury, habitual use of hairpins to relieve irritation, the entrance of water into the auditory meatus, draughts, the extension of an inflammatory process along the auditory meatus, the too forcible use of Politzer's bag, and the injudicious use of the nasal douche may be immediate causes of chronic disease.

Unhealthy environment, mal-nutrition, neglect of or improper treatment, and the wearing of cotton wool are also important causative factors.

In exceptional cases chronic disease arises without any marked reactive phenomena as in certain forms of cachexia, tuberculosis, and diabetes.

Tuberculous disease of the middle ear is usually regarded as running a chronic course *ab initio*, its characteristic features being a painless and asthenic course, the presence of one or more perforations of the membrana tympani, and the tendency to the production of facial paralysis and enlarged peri-auricular glands.

The exact influence of micro-organisms in the induction of chronicity is still *sub judice*, many observers, however, regarding a secondary staphylococcic infection as a frequent proximate cause. Recurrent acute attacks are also largely responsible for chronicity.

Suppurative disease of the middle ear, both acute and chronic, is more frequent in children and young adults than in later life, mainly because of excessive patency of the Eustachian tubes, their more horizontal direction, and their nearness to the oral cavity, which renders them at all times liable to infection, but more especially during the exanthemata, and the various affections of lymphoid structures—enlarged tonsils, naso-pharyngeal adenoids,—which are more frequent at this particular period of life. Dentition, congenital syphilis, and catarrhal affections of the upper respiratory tract are also important agents in the production of middle-ear disease in children.

In chronic suppurative middle-ear disease the whole middle-ear tract is involved, although from the formation of inflammatory adhesions and the presence of pouches the morbid process may ultimately become localised.

Morbid Anatomy.—Were the morbid changes which constitute chronic suppurative inflammation of the antro-tympanic cavity restricted to its lining membrane, their description would be comparatively easy and simple. But in addition to the peculiarities in the shape of the cavity, which renders ventilation and drainage at all times difficult, any local swelling may easily lock up septic products and cause serious complications, by reason of its free communication with the labyrinth and cranial cavity. There is, however, another feature which favours extension of disease, viz., the structure and intimate attachment of the muco-periosteum, which is such as to render the bone specially liable to involvement in the morbid process, if it be of a high grade of severity, since the vascular supply of the two structures is so intimately associated. In fact it is upon an accurate appreciation of the existence and extent of the osseous lesions that prognosis and treatment will chiefly be based.

Should the primary attack have been only moderate in duration and intensity, areas of normal epithelium will soon enlarge, and coincidentally with the arrest of bacterial infection will rapidly line the whole cavity. But if hyperaemia, sepsis, and a perforation persist, the epithelium will undergo squamous metaplasia, owing to constant irritation, probably from the tryptic products of dead leucocytes and bacterial toxins, or from extension inwards of epidermis. Should these squames accumulate, a cholesteatomatous process is established, which may involve the antrum, and is generally attended by considerable thickening of the muco-periosteum. So long as a cholesteatoma remains free from re-infection it may cause no symptoms, although, by gradual pressure, the osseous cavity in which it lies may be considerably expanded.

On the other hand, should excessive and rapid desquamation cease and the scales find a ready exit, the antro-tympanic cavity will simply retain its thin squamous lining, but owing to excessive transudation of serum and imperfect drainage it will remain constantly moist, and becomes practically a "septic tank" containing an albuminous fluid in which bacteria, especially foetid facultative anaerobes, flourish.

The discharge in such a condition is highly typical, it is often profuse, opaque, and intensely foetid, containing swarms of bacteria such as *spirochaeta foetida*, *bacillus butyricus*, *bacillus proteus vulgaris*, *staphylococci*, *torulae*, etc., for the most part "throat organisms" which probably have travelled *per tubam.* But the most striking feature is an entire absence of leucocytes, the only cells present being occasionally a few squames.

Should the inflammatory activity in the muco-periosteum not subside, a chronic exudative process is established with increased swelling of the membrane, accentuated around the fenestrae, the ossicles, the *ostium tubae tympanici*, and the *aditus ad antrum*, which eventually gives rise to a low type of granulation tissue. It is to obliteration of the *fossula* *rotunda* and *pelvis ovalis* by granulation tissue that persistent deafness is so often due. When this is locally accentuated in the shape of pedunculated masses and polypi, caries may be suspected.

The discharge in such conditions is very characteristic, being marked by the presence of leucocytes, old and recent polymorphonuclear and large mononuclear cells, with a high percentage of lymphocytes whose presence is strong evidence of the existence of granulation tissue. Endothelial cells, plasmocytes, and a varying but small proportion of phagocytes may also be seen along with bacteria of all kinds (Plate IV. Fig. 2).

If not already present, bone disease is sooner or later developed, the bony walls of the tympanum being so closely intimate with and dependent upon the muco-periosteum for their nutrition. If not already established, a cholesteatoma will now gradually form and fill the antrum and epitympanum. This type is at all times liable to acute exacerbation owing to re-infection with such bacteria as *diplococcus catarrhalis*, *Pfeiffer's bacillus*, *bacillus septus*, *bacillus capsulatus mucosus*, *pneumococcus*, *streptococcus*, *staphylococcus*, etc., the discharge then assuming the character of an acute suppuration with excess of recent polymorphonuclear leucocytes, phagocytes, and when complicated by osteomyelitis of the mastoid with myelocytes.

Owing to extension and intensification of the process the surrounding bone is almost sure to be involved, especially the cancellous areas in front of and behind the labyrinth, and also that of the mastoid element.

There is one important group of this type which is characterised, if not actually caused, by a streptothricial infection of an acid-fast form of that family, which may run a rapid or a slow course. As it is invariably associated with pyogenic bacteria it is somewhat difficult to say which organism is responsible for the rapid toxaemia and suppuration so often present. These acid-fast bacilli are generally found in groups or felted masses of long and short-beaded filaments sometimes placed parallelwise, in other cases crossed and branching. They are usually not alcohol-fast, a fact which distinguishes them from the tubercle bacillus, but are + to Gram and Neisser stains. They are often associated with profound toxaemia, and may prove fatal even when uncomplicated by sinusal or cerebral trouble. There is, however, always caries, and the discharge is extremely foetid and of the butyric type.

Other varieties of acid-fast bacilli are present in chronic cases whose peculiar power of retaining fuchsin is probably acquired from exposure to butyric acid or lipoid substances. The tubercle bacillus is, however, acid- and alcohol-fast intrinsically.

With regard to osseous lesions they vary widely in situation, extent, and type. Whenever granulations are persistent careful probing will frequently reveal bare bone. If due to caries it will be rough, spongy, and painful, while a firmer and smoother surface will be suggestive of necrosis, a not uncommon sequel to acute suppuration of severe intensity. Necrotic bone also yields a greater foetor in the discharge, but

PLATE IV

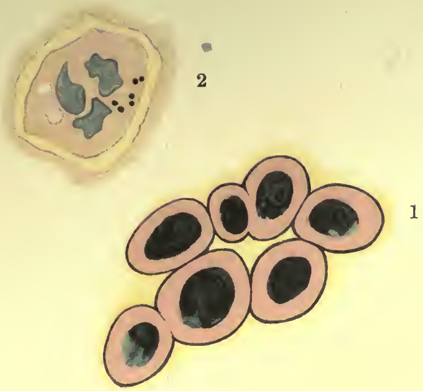


Fig. 1.

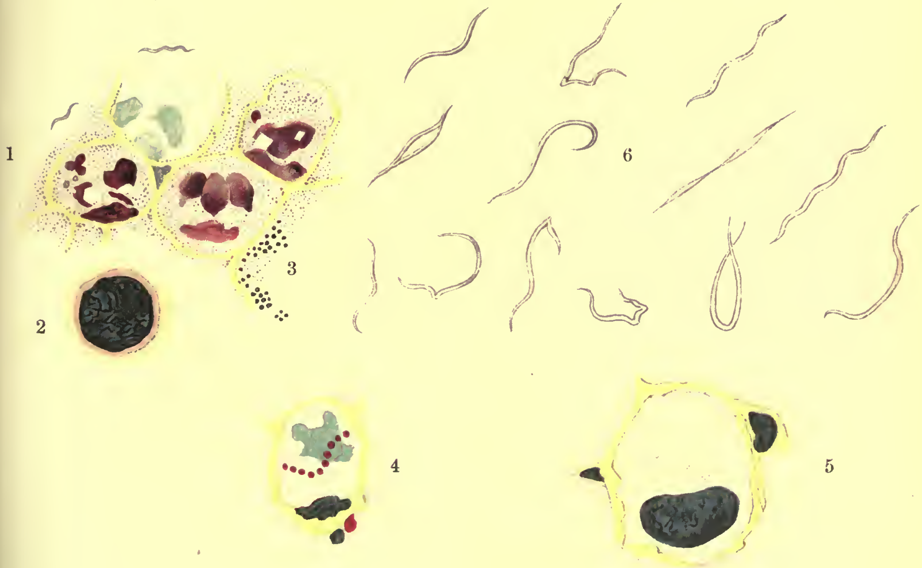


Fig. 2.

Fig. 1.—Acute suppurative otitis media.
1. Tympanic epithelium. 2. Leucocyte containing diplococci.

Fig. 2.—Chronic suppurative otitis media with caries.
1. Leucocytes. 2. Lymphocyte. 3. Staphylococci. 4. Leucocyte containing fragment of another nucleus and streptococci. 5. Myelocyte. 6. Spirochaetae.

cytological evidence is more marked in acute osteomyelitis in the shape of myelocytes.

Caries will often be found in the ossicles, tegmen tympani, tegmen antri, sigmoid groove, antrum and adjacent part of mastoid, and in the cancellous bone behind the labyrinth, less frequently in front of the labyrinth and tegmen tubae. But it may also extend to the basi-occipital and basi-sphenoid bones, especially if tuberculous, when the discharge will be somewhat scanty, watery, and curdy, containing, along with other bacteria, tubercle bacilli, sometimes endothelial and giant cells and relatively more lymphocytes than leucocytes. Bone particles also may be present, and are easily recognised on preparing the film.

Such important complications as extension to the labyrinth and facial canal, thrombosis and infection of the sigmoid groove and sinus, subdural suppuration, and brain abscess will each be specially dealt with. Coincidentally with all kinds of middle-ear infection the pre- and post-auricular glands, together with the cervical, superficial and deep, are very often the seat of acute or chronic inflammation.

A thorough knowledge of the nature of the discharge is at all times of no small value, but is indispensable in connection with opsonic treatment, especially when supplemented by the employment of the local "lymphagogue" principles of Wright.

Unfortunately, owing to the polymicrobic nature of chronic middle ear suppuration, there is some difficulty in identifying the particular organism which is responsible for the chronic infection. This, however, applies less to tubercle than to any other form; still, owing to the morphological and staining mimicry of some acid-fast bacteria, its diagnosis may be attended with doubt, and demand the support of other evidence. But there can be no doubt whatever of the value of the cytological evidence afforded by the degree of phagocytosis and the different varieties and states of leucocytes as guides in connection with the local employment of Wright's citrated saline.

Symptomatology.—In many cases a discharge from the ear and a certain degree of impairment of hearing are the only symptoms complained of. In other cases, however, recurring attacks of pain, tinnitus, and vertigo are not uncommon. Disturbances of taste and smell are also occasionally complained of. Pain is, as a rule, slight, except in those cases when intercurrent attacks of acute inflammation supervene, or when the exit of discharge is interfered with from the presence of tufts of exuberant granulation tissue, polypi, sequestra, or stenosis of the meatus. Suppuration round a cholesteatoma is also accompanied by severe pain and high fever. In a chronic case the advent of pain is frequently an indication of the commencement of some severe and often fatal complication, and should always be regarded, in the absence of any definite local cause, with grave suspicion. Deep-seated boring pain is indicative of labyrinthine involvement, while a constant and aching pain in the head is suggestive of incipient intracranial abscess.

Impairment of hearing during active suppuration.—The degree of deafness met with in chronic cases varies greatly, and is dependent not so much upon the amount of destruction of the membrana tympani as upon the damage inflicted upon the contents of the middle ear and the presence or absence of labyrinthine involvement. In many cases, when extensive destruction of the membrane has taken place, comparatively trivial defects of hearing may exist, whilst in other cases, with only a minute perforation, high degrees of deafness are at times met with.

The factors of main importance in the maintenance of good hearing are the integrity of the stapedio-vestibular articulation, and the cochlear and vestibular windows and membranes, since the presence of secretion in the middle ear, intratympanic adhesions, an oedematous or polypoid mucosa, partial loss of the ossicular chain, and secondary implication of the labyrinth seriously affect the powers of audition. In cases of epitympanic disease with perforation of Shrapnell's membrane there is frequently very slight loss of hearing power.

Various external causes modify the acuity of hearing. In dry and bracing weather it is invariably better than in wet and windy states of the atmosphere. Residence in a low-lying and damp situation acts, as a rule, deleteriously, whilst hill air and residence in a hot and dry or cold and dry climate is beneficial. Residence for any length of time at the seaside tends to impair audition in cases of chronic suppurative otitis media.

Intercurrent attacks of nasal or nasopharyngeal catarrh, coincidental tonsillar, oral, and nasal accessory sinus sepsis, exhaustion following acute general disease, and impairment of general health from any cause whatever have also a distinctly baneful effect.

Tinnitus is not, as a rule, a marked symptom in chronic purulent disease of the middle ear. When present, it is due either to commencing stapes-anchylosis, to the formation of intra-tympanic adhesions, to the pressure of pent-up secretion, or to secondary implication of the auditory nerve terminals. The fact that the perforation in the membrana tympani permits of equalisation of pressure upon its two sides, probably explains its comparative rarity. When tinnitus is present it is as a rule intermittent, and is influenced to some extent, at least, by the idiosyncrasies of the patient. It is as a rule worse and more persistent in neurasthenics and those suffering from anaemia and general debility.

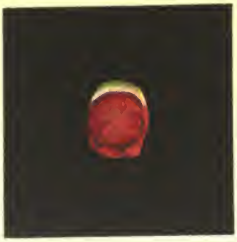
When persistent, especially if high pitched, it must be regarded as of bad omen.

Vertigo may be due to a concomitant labyrinthine congestion, to pressure upon the footplate of the stapes or membrana secundaria, or to co-existing suppurative disease of the vestibule or semicircular canals. Its persistence in any chronic case should always be regarded with suspicion.

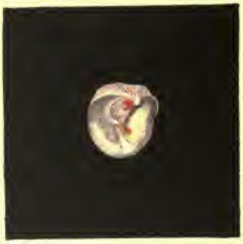
Disturbance of taste and smell, especially of the former, are frequent, and are due either to implication of the chorda tympani in its passage through the middle ear, or to the escape of putrid secretion along the

PLATE V

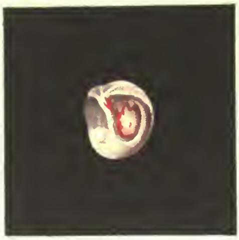
CHRONIC SUPPURATIVE INFLAMMATION OF THE MIDDLE EAR



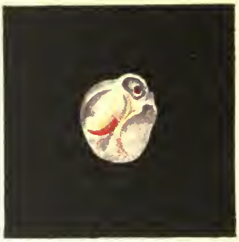
Polypus auris.



Calcareous deposit. Cicatrix.



Perforation of posterior segment with exposure of the stapes.



Perforation in Shrapnell's membrane. Bare bone felt through perforation with probe.

From the author's article upon Chronic Suppurative Otitis Media in Allbutt and Rolleston's *System of Medicine*, vol. iv. pt. ii. (Macmillan and Co.).

To face page 2

Eustachian tube into the pharynx. Perversion of smell may, however, be a purely subjective phenomenon.

Ocular Signs.—J. S. Barr and J. Rowan[1] have called attention to the frequent presence of optic neuritis or vascular changes in the fundus in cases of purulent otitis media without obvious signs of any intracranial complication. In 160 cases optic neuritis was found 11 times (6 to 8 per cent) and vascular changes of a less degree 39 times, or in nearly 25 per cent of the cases examined. They regard cases of purulent middle-ear disease, where optic neuritis or vascular engorgement of the fundus is present, as less amenable to treatment than those where the fundus is normal. They also consider the presence of such changes an additional reason for the early performance of the radical mastoid operation.

Objective Appearances.—The most striking feature of chronic suppurative otitis media is the presence of a discharge from the ear. The amount and its characteristics vary within wide limits. At times it may be very profuse and fluid, at other times scanty, tenacious, and even viscid. It may be thick, yellow, and purulent, or thin, watery, and almost white in appearance. It may be yellowish-red from the presence of blood cells or of a bluish colour from the presence of the *bacillus pyocyaneus* or of a greenish hue from the presence of the *bacillus fluorescens*. It is, at times, quite odourless, at other times extremely foetid from the presence of putrefactive bacteria, *e.g. bacillus proteus vulgaris*, *spirochaeta foetida*, and various saprophytic organisms. It may contain macroscopic flakes of concentrically arranged epithelium, when complicated with the presence of a breaking down and infected cholesteatoma or small gritty particles when there is co-existing disease of the temporal bone. A minute and microscopical examination of the discharge always affords evidence of great practical value, indicating as it does, at times, the character of the underlying morbid process, and, to some extent, at least, the actual source of the suppuration (see Chap. XIX.).

The discharge is most profuse in cases of exanthematous origin, when there are masses of exuberant granulation tissue, with or without the presence of osseous lesions, and when the adjacent cellular elements of the mastoid process are simultaneously infected. In many cases the discharge is peculiarly thin, irritating, and acrid, causing excoriation of the meatal walls and even of the auricle itself, which, according to Wright,[2] is due to tryptic products from degenerated pus cells or leucocytes. This is especially prone to be the case when extensive caries is present, as occurs in tuberculosis.

The Appearance of the Membrana Tympani.—As a rule there is only one perforation, although two, and at times even three or four, are seen in cases of tuberculous or diphtheritic origin. The perforation varies much in size, shape, and situation. It may be so small as to be scarcely visible without the aid of a magnifying speculum, or so large as to practically occupy the whole of the membrane. Within these wide limits all shapes and sizes of perforations are to be found.

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[1] *British Medical Journal*, March 26, 1910.

[2] *Practitioner*, May 1908.

In the membrana tensa the perforation may be situated anteriorly or posteriorly to the handle of the malleus, or may occupy its lower segment. It may be peripheral or central, circular, oval, heart-shaped, reniform, or almost linear (Fig. 114).

The objective appearances of the edges of the perforation afford some clue as to its age; thus, in comparatively recent perforations, the edges have a pinkish or reddish appearance, whilst in chronic cases the edges are thick and indurated, due to their epidermisation.

The more chronic the case the thicker the edges of the perforation, and the greater the tendency to assume an almost circular shape. In chronic cases also, patches of cretaceous degeneration are frequently to be found in its immediate neighbourhood. As a rule the perforation is readily visible except when it is a mere pin-point opening, or when the discharge is so profuse as to conceal it from view, or when some undue projection (physiological) of the meatal walls prevents proper inspection. In such cases, its position may be recognised from the presence of a pulsating light reflex, or from the escape of pus or air following inflation of the middle ear or rarefaction of air in the auditory meatus.

The position of the perforation has also a certain significance, which is often of clinical importance. Thus a perforation more or less centrally situated is, as a rule, associated with, and dependent upon Eustachian infection or obstruction with inefficient drainage; if situated along the inferior margin of the membrane, it is indicative of caries of the inferior wall or tympanic floor; if at the margin of the postero-superior quadrant, it is prone to be associated with caries of the ossicular chain (more especially the incus) and of the bony walls of the antrum.

In the *membrana Shrapnelli* the perforation may be extremely minute, and is frequently situated so far forward and so valvular in shape as to be hardly visible. At other times it may be so large as to completely expose the recessus epitympanicus with its contained ossicles.

Prognosis.—The existence of chronic suppurative disease of the tympanic mucosa is always attended with an element of danger because it is not possible to foretell when or how the disease will terminate. From a practical point of view the prognosis of any given case should be considered:—(1) In relation to the cessation of discharge, (2) in relation to the preservation of hearing power, and (3) in reference to the various risks to life. The original predisposing and existing causes of purulency, the particular segment or segments of the middle-ear cleft involved, the duration, and the various objective evidences of disease are important factors in deciding the question.

Exanthematous disease affecting the middle ear is, as a rule, more dangerous and more destructive than disease due to ordinary catarrhal causes. The longer the disease has lasted, the greater as a rule the destruction of tissue, and the greater the liability to osseous infection. The type and virulence of the particular organism or organisms responsible for the incidence of suppuration are important. For this reason it is advisable in every chronic case to make a bacteriological examination of

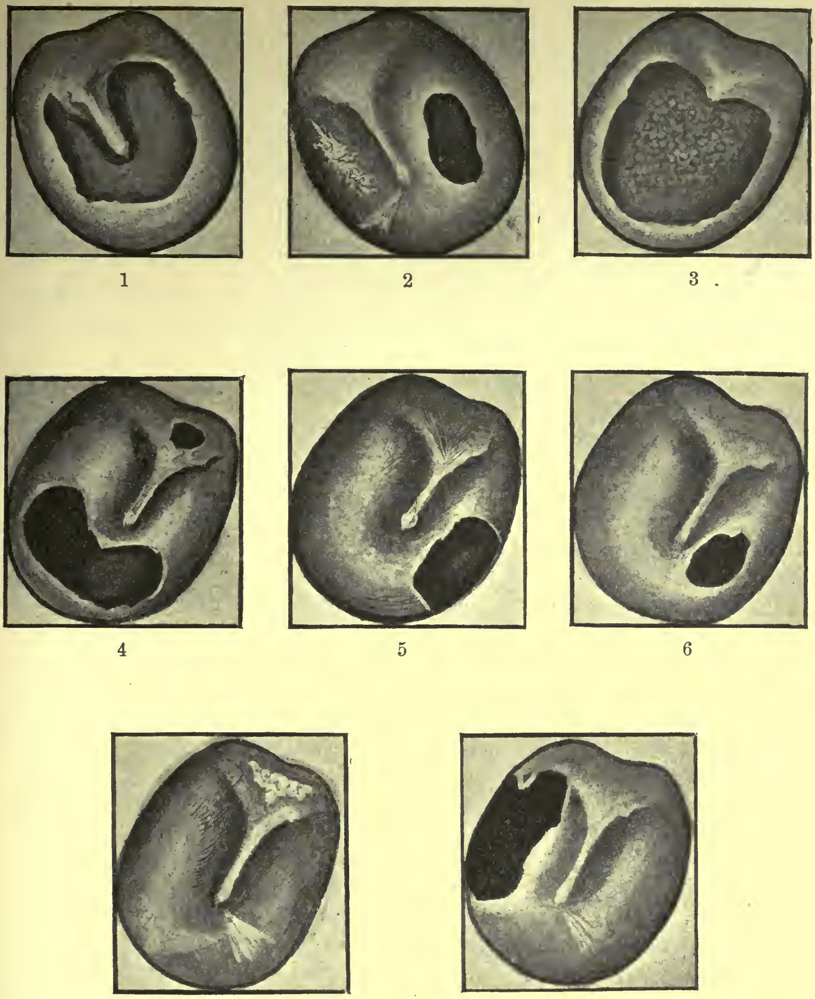
1 2 3 4 5 6 7 8

FIG. 114.—Various shapes and sizes of perforation.

1. Large perforation of membrana tympani exposing inner wall of middle ear.
2. Perforation of posterior segment, calcareous patch in anterior segment.
3. Almost complete destruction of membrana tympani ; granular mucous membrane of middle ear.
4. Kidney-shaped perforation.
5. Marginal perforation of anterior segment associated with caries of anterior wall of meatus.
6. Perforation of anterior segment associated with chronic tubal catarrh.
7. Perforation of Shrapnell's membrane bone granulations.
8. Perforation of posterior segment of membrane and exposure of stapes associated with a cholesteatoma.

the discharge removed with a sterilised platinum loop from the depths of the cavum tympani.

The danger to life depends largely upon the presence or absence of osseous lesions in and around the cavity of the middle ear and its accessory spaces. The longer the disease has lasted the greater the liability to involvement of bone, whilst the exact site of caries or necrosis is all-important. Thus disease of the roof of the middle ear or mastoid antrum is liable to be followed by erosion exposing the dura of the middle fossa; disease of the posterior antral wall, by perisinusal abscess, lateral sinus thrombosis or cerebellar abscess; and disease of the inner tympanic wall by septic invasion of the labyrinth with the possibility of its extension to the base of the brain.

Although as a general rule infection is prone to spread to adjacent organs by way of osseous erosions, it may also spread by vascular or lymphatic channels.

In general, disease of the atrium of the middle ear is more amenable to treatment than disease of the *recessus epitympanicus.*

The prognosis is more favourable in the young and healthy, amongst those who live in good surroundings, when there has been no previous disease of the middle-ear cleft, and when the discharge, although profuse is purely putrefactive, and free from lymphocytes. Various local conditions and phenomena may be regarded as favourable signs, *e.g.* the presence of a moderate amount of non-foetid purulent discharge, and of a perforation of sufficient size and so situated as to favour efficient drainage, a permeable Eustachian tube and a smooth non-granular condition of the tympanic mucosa.

The prognosis is less favourable when the disease is the result of the exanthemata, diphtheria, influenza, typhoid fever or tuberculosis, and in those cases where there exists chronic nasal or nasopharyngeal catarrh or accessory sinus disease.

In addition various local conditions materially modify the outlook, *e.g.* stenosis of the Eustachian tube or auditory meatus, a granular or polypoid tympanic mucosa, a small perforation, a marginal perforation, profuse foetid discharge, caries of the tympanic parietes, necrosis, cholesteatomatous degeneration, paralysis of the facial nerve, or implication of the accessory cavities of the middle ear.

The prognosis, so far as the function of hearing is concerned is frequently difficult to determine, partly because much temporary deafness may exist, due to such causes as a swollen tympanic mucosa, obstructed labyrinthine windows, and congestion of the internal ear, all of which may rapidly subside as the suppurative process comes to an end. When marked improvement ensues as the result of inflation, and especially when this improvement is maintained for a few days, the prognosis may be regarded as distinctly hopeful. When on the other hand there is no improvement after inflation or at the most a very temporary one, the prognosis is grave. The prognosis is favourable in those cases where only a slight degree of deafness remains after cicatrisation of the membrane, while it is distinctly unfavourable when an increased impairment of hearing takes place after cicatrisation.

Treatment.—The main objectives are :—

1. The provision of free and unimpeded drainage and ventilation of the middle-ear.
2. Surgical cleanliness.
3. The use of antiseptic remedies.
4. Treatment of pathological conditions of the upper respiratory tract.
5. Cytological examination of the discharge.
6. The post-auricular exposure of the posterior end of the middle-ear cleft, and the following up of paths of septic infection.

In many chronic cases the infection is by no means very virulent, and recovery rapidly ensues after the provision of free drainage and the employment of antiseptics. In other cases the existing perforation is so situated or is so small as to prevent the free egress of discharge. Under such circumstances it should be enlarged, and if possible maintained open in its whole length.

Tufts of granulation tissue or polypi should be removed with forceps (Hartmann), curette, snare, or cautery. The patency of the Eustachian tube should be maintained by regular inflation with the air douche, or by catheterisation, and, if need be, by the injection of a warm alkaline antiseptic lotion, while nasal and post-nasal growths interfering with its normal physiological function or mechanically blocking it should be removed, prior to the institution of local treatment.

To cleanse the cavity of the middle-ear and contributory paths of infection, the following plan may be adopted with advantage :—

1. Inflation of the middle ear with the air-douche.
2. Syringing the auditory meatus with a warm alkaline antiseptic lotion or warm sterilised water.
3. Aspiration by means of Siegle s pneumatic speculum or Sondermann's apparatus.
4. Re-inflation with the air-douche.
5. Syringing again or drying the meatus with sterilised wool. In this way the infected antro-tympanic tract is as completely cleansed as is possible, and all "residual" secretion lying on the floor of the middle ear got rid of. The exact plan of treatment to be adopted should depend upon the amount and character of the discharge, the frequency with which the patient can be seen, and his habits and surroundings. The principal methods of treatment are :—

1. The employment of fluid remedies, namely, antiseptic and astringent lotions.
2. The insufflation of antiseptic powders.
3. The removal of the contents of the middle ear by tampons or wicks of antiseptic gauze.

Each plan of treatment has its advantages and disadvantages, and care should be taken to select that method most likely to be efficacious in a given case. Thus, when the discharge is copious, and when it is possible to examine the patient only at long intervals, treatment by means of antiseptic lotions is preferable. When, on the other hand, the discharge is scanty, the perforation large, the middle ear well drained, and the patient under observation, the dry method of treatment, either by means of the inflation of antiseptic powders, or packing the meatus with gauze, may be employed with great advantage.

Whichever lotion is selected for use should be allowed to remain in the auditory meatus and in actual contact with the diseased tympanic mucosa for at least ten minutes twice a-day, the head being meanwhile horizontal. Its entrance into the tympanum should be assisted by the frequent performance of a negative Valsalva, and by gentle to-and-fro compression of the tissues in front of the tragus.

When the discharge is thin, muco-purulent, and non-foetid, warm sterilised water (92° F. to 96° F.) may be used for syringing. On the other hand, when it is thick, tenacious, and purulent, the addition of a solution of sodium sulphate (2 per cent) with sodium biborate (0·5 per cent) or of common salt to the sterilised water is of advantage. Should the discharge be foetid an antiseptic lotion such as carbolic acid (1 in 40), bichloride of mercury (1 in 3000), formalin (20 drops to a pint of warm water), lysol (1 to 2 per cent), creoline (1 to 2 per cent), or boracic acid (gr. xx. to 1 oz.) may be used. In children, and in those cases where the Eustachian tube is very patent, mercurial preparations should be sparingly employed.

After having cleansed and dried the ear with a tampon of wool or gauze, the particular lotion to be employed for healing purposes should be instilled into the meatus. The patient should be instructed to lie down upon a bed or sofa with the affected ear uppermost. The auricle should now be drawn upwards and backwards so as to straighten the auditory meatus, and the lotion, previously warmed, poured in until it is quite full. The lotion should be retained in the meatus for at least ten minutes, so as to give it time to act upon the diseased tympanic mucosa. At the end of that time the excess which has not been absorbed may be allowed to run out, after which the meatus is dried and packed with a strip of gauze or a plug of antiseptic wool. When the perforation is situated anteriorly the patient's head, after the meatus has been filled with the lotion, should be inclined backwards, so as to permit of the lotion reaching the posterior parts of the middle-ear cleft. The alternate performance of a positive and negative Valsalva whilst the lotion is *in situ* materially assists its entry into the middle ear. When, however, the Eustachian tube is stenosed, inflation by forcing air through the middle ear permits of the entry into the tympanum of the lotion lying in the meatus. When the perforation is situated in Shrapnell's membrane special intra-tympanic syringes should be used (see Chap. XVII.) for cleansing purposes.

In cases of very obstinate discharge, when the secretion is peculiarly blennorhoeic or gelatinous, the washing out of the middle ear *per tubam* is frequently very effectual. As in all chronic cases the whole antro-tympanic tract is more or less infected, the forcible injection of fluid *per tubam* serves to cleanse not only its mucosa but also the mucosa of the posterior end of the middle-ear cleft. This method is particularly advantageous in those chronic cases associated with excessive granularity of the tympanic mucosa, with polypoid granulations constantly protruding through the existing perforation and tending to stagnation of secretion, and when from one or other cause the external auditory meatus is so stenosed as to prevent efficient cleansing from without. Sterilised normal salt solution or weak boracic lotion will be found serviceable as intra-tympanic injections.

As a rule vertigo may be prevented if the fluid is injected very slowly and with a gradually increasing pressure and by previous removal of all obstructing granulations. Should it become troublesome, aspiration with a Siegle's speculum affords immediate relief.

The choice of the particular medicament for instillation is a matter of some difficulty. In general drugs possessing antiseptic and slightly caustic properties will be found the most useful. The addition of rectified spirits is advantageous, owing to its power of abstracting watery fluid from the oedematous mucosa and of coagulating its albuminous elements. Care should, however, always be taken not to employ solutions which by a too caustic action impair the vitality of the already weakened mucous membrane. Although it is impossible to maintain anything like surgical asepsis of the middle-ear tract, owing, on the one hand, to its communication with the air through the external auditory meatus, and, on the other hand, with the nasopharynx through the Eustachian tube, which in all cases of chronic suppurative middle-ear disease is septic, yet the regular employment of antiseptic remedies will be found in actual practice to be attended by a speedy improvement if not actual cessation of purulency. When there is co-existing disease of the temporal bone, implication of the accessory cavities of the middle ear, or extensive cholesteatomatous degeneration, it is evident that something more than merely antiseptic cleansing of the infected middle ear will be required. If, however, the case is one of simple uncomplicated purulent disease of the antro-tympanic mucosa, with a discharge free from cells, most gratifying results are obtained by the regular employment of antiseptic remedies, or Wright's citrated hypertonic salt solution and the maintenance of free drainage. The medicaments which practical experience has shown to be the most efficacious are solutions of carbolic acid, especially glycerine of carbolic acid (5 per cent), resorcin (gr. vi. to oz. 1), sulphocarbolate of zinc or soda (gr. vi. to oz. 1), nitrate of silver (gr. x.-xx. to oz. 1), boracic acid (gr. xx. to oz. 1), perchloride of mercury (1 in 2000), and hydrogen peroxide (ʒii. to oz. 1), with or without the addition of boracic acid. When squames accumulate a 3 per cent solution of salicylic acid in alcohol, followed by a solution of bicarbonate or biborate of soda, is useful.

The tympanic lining may be readily dried by the application of hot air, a specially constructed electric apparatus being employed for the purpose. Previous to the application of the instrument the Eustachian tube should be inflated by the air-douche or catheter.

Hot air has the advantage of thoroughly drying the tissue and so hindering the growth of bacteria. The air should not be so hot as to cause any unpleasant symptoms, *e.g.* sickness or vertigo, or any inflammatory reaction.

Carbolic acid, besides possessing strong antiseptic properties, has the further advantage of acting as an analgesic. If used in too strong solution, however, it causes a very irritable condition of the auditory meatus. When combined with glycerine it possesses greater powers of penetration. Resorcin in 4 per cent watery or alcoholic solution is of great value in those cases in which the secretion from the middle ear is peculiarly viscid and muco-purulent.

Boracic acid in watery or alcoholic solution is a mild and unirritating preparation, and is as a rule well borne, but it has no antiseptic power.

Perchloride of mercury lotion, either in aqueous or alcoholic solution, is of great value in cases of obstinate sepsis combined with foetor. It may be used in strengths of from 1 to 3000 to 1 to 1000, according to the nature of the case and the age of the patient. It is advisable to begin the treatment with comparatively weak solutions, gradually increasing their strength as the tissues become accustomed to the drug. It should not be used in the case of young children, nor for more than a few weeks at a time.

Hydrogen peroxide acts as an excellent antiseptic and oxidising agent, owing to its peculiar property of liberating free oxygen when in contact with pus or blood owing to rapid effervescence. It may be used in 20-volume strength or diluted with varying amounts of distilled water. The writer as a rule uses a 20-volume solution (Marchand's), diluted with an equal quantity of distilled water. The solution should be slightly warmed before introduction into the ear, and forced by pressing the tragus backwards towards the meatus into the recesses of the cavum tympani. The liberation of gas which takes place forces the fluid into the recesses of the middle ear, and in this way effects a very thorough disinfection of infected areas. The greater the amount of discharge and sepsis the greater the foaming and frothing of the secretion. Conversely as the frothing becomes less and less, so one may expect to find a continuous improvement in the condition of the infected cavities. According to Politzer the effect of hydrogen peroxide may be increased by the addition of boracic acid (1 to 40).

Owing to the extreme density of most aural discharges, experience has taught that it is expedient to separate their removal from the more important sterilising process. As pointed out by one of us,[1] most discharges contain a high percentage of albumin and globulin, which are precipitated by most antiseptics, but are soluble in neutral and alkaline salts, such as sodium chloride, sulphate, biborate, and carbonate. A preliminary cleansing with such solutions enables the succeeding antiseptic to more effectually do its work. Owing to chemical incompatibility also their separate employment is demanded.

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[1] "The Nature of Discharges and Douches," W. Wingrave, *Lancet*, 1902.

Many other antiseptic solutions are in almost daily use, and are extolled by this and that writer. The authors have, however, named only those solutions which their practical experience has shown to be of value. Whichever antiseptic or combination of antiseptics is selected, should not be used for more than a fortnight at a time, in the event of no marked improvement taking place. Even when improvement does take place it is advisable to change the drug from time to time.

Of late years the use of rectified spirits, originally introduced by Loewenberg and Weber-Liel, either pure or in dilute solution, has come much to the front. 'Alcoholic solutions are of special value in those chronic cases where the mucosa is markedly granular or even polypoid. As the instillation of warm rectified spirits into the ear is usually at first distinctly painful, it is advisable to commence with dilute solutions (20 to 40 per cent), gradually working up to a 50 per cent dilution, which is held by many to have more powerful antiseptic properties than even pure spirit. To mitigate the pain so far as is possible it is advisable to instil in the first place only a few drops of the dilution, and then in the course of five minutes to fill up the meatus. The effect of the instillation of alcohol is to cause an immediate blanching of the tissues, a coagulation of the albuminous elements of the secretions, and a general dehydration of the oedematous mucosa.

In cases where the discharge is very septic and foetid alcoholic solutions of carbolic acid, resorcin, boracic acid or mercury will be found serviceable.

The instillation of alcohol is contra-indicated in cases of caries of the temporal bone, and when it produces continuous pain and headache.

In cases of protracted suppuration, more especially when there exists a large defect in the membrane and an oedematous hypersecretory condition of the mucosa, the instillation or local application of nitrate of silver lotion (gr. 30 to 40, oz. i.), in virtue of its caustic properties, has at times a most beneficial effect upon the course of the disease.

After careful cleansing of the meatus 15 to 20 drops of the warmed nitrate of silver lotion are carefully dropped into the ear from a small pipette or applied with a cotton-tipped probe. The immediate result is the production of a whitish eschar. When the application produces severe pain the ear should be at once syringed with warm sterilised water and a few drops of a 5 per cent solution of cocaine in normal saline solution instilled. In the course of five minutes the ear should be carefully dried with absorbent wool and the silver solution again instilled. The eschar so produced becomes detached, as a rule, within from twenty-four to forty-eight hours.

After several such applications the discharge will usually become distinctly less, if not completely arrested.

Solutions of nitrate of silver should not be employed in those cases where only a small perforation of the membrane exists, in cases of cario-necrosis, or where the tympanic cavity is full of granulation tissue.

Astringent lotions which formerly were much made use of have to a very large extent been superseded by antiseptic, caustic, or alcoholic methods of treatment. Such drugs as chloride of zinc, sulphate of copper, sulphate of zinc or alum, although possessing markedly astringent properties, are at the same time prone to defeat their object by producing an accumulation of insoluble albuminates. In conjunction, however, with antiseptics and in sufficiently dilute solution they will be found valuable adjuncts in helping to restore an oedematous mucous membrane to a state of health.

The dry method of treatment of chronic suppuration of the middle ear by means of the insufflation of antiseptic powders is of service in those cases where there is a large perforation of the membrane, when the discharge is not profuse and not markedly foetid, and when the patient can be kept under regular observation. It is contra-indicated if the perforation is small and the discharge profuse, if active inflammatory signs are present, and in young children.

Such powders as boracic acid (Bezold), boracic acid and iodoform (1 to 4), aristol, europhen, iodol, iodoform, orthoform, and resorcin, are the ones in general use.

After having carefully cleansed and dried the ear with wool or gauze, a small quantity of powder is blown through an insufflator into the auditory meatus, so as to completely cover the perforation and the exposed lining of the middle ear. So soon as inspection shows that the powder has been soaked by discharge it is removed by syringing and a fresh insufflation made. In certain cases this may have to be done once a day, more usually, however, once every second or third day.

The method is contra-indicated in acute exacerbations of the disease, and in the presence of an *otitis externa*.

Aspiration of the purulent contents of the middle-ear cleft may be advantageously employed in those cases where the amount of discharge is not profuse and where, from the habits and surroundings of the patient, any interference, save professional, is undesirable.

After a preliminary cleansing of the ear a strip of gauze six inches long by three-quarters of an inch broad is carefully packed into the external meatus, and, if possible, so that it actually enters the cavum tympani. Iodoform, double cyanide, boracic, xeroform, aristol, or airol gauze may be employed. The writer, as a rule, employs iodoform gauze which has been soaked in 1 in 40 carbolic oil squeezed almost dry and cut into strips of suitable length and breadth. The gauze packing is changed every two or three days according to the amount and character of the discharge.

Instead of employing gauze tampons, pledgets of antiseptic wool, *e.g.*

boracic, salicylic, thymol, or iodoform, may be twisted into suitable shape and inserted into the meatus.

In addition it is desirable to instruct the patient to wear a specially prepared pad lined with antiseptic wool over the auricle, or a wire shield similar to a vaccination protector, as in this way the chances of external contamination are reduced to a minimum.

In many cases of chronic suppurative middle-ear disease the lining of the middle-ear cleft is in a state of granular degeneration, and upon examination presents the appearance of a red vascular and mamillated surface. Such exuberant granulations may or may not be connected with an underlying focus of caries. They are most frequently found upon the inner tympanic wall, the floor of the tympanum, and the outer surface of the membrana tympani. Their presence indicates deep-seated changes in the mucosa and a marked tendency to chronicity, while a cytological examination of the accompanying discharge will reveal the presence of numerous leucocytes, old and recent, with a high proportion of lymphocytes.

This form of suppuration is peculiarly difficult to arrest. The first indication is to destroy the granulomata. At times this may be accomplished by the continuous instillation of rectified spirit or alcoholic solutions of boracic acid, perchloride of mercury or resorcin. More frequently, however, it is necessary to destroy them by the application of chemical caustics, or to remove them mechanically by means of spoon-shaped curettes or forceps.

In other cases when the granulations are clearly visible the local application of sesquichloride of iron, nitrate of silver, chromic acid, trichloracetic acid, or anhydrous phenol applied dry is advisable. After having carefully cleansed and anaesthetised the infected region, a cotton-tipped probe is taken, charged with the particular medicament to be employed, and applied carefully and under good illumination to the granular surface. The eschar thus formed is allowed to detach itself before any subsequent application is made.

The sesquichloride of iron and chromic acid have, as a rule, afforded the best results. Nitrate of silver even in strong solution has not the penetrating capacity of either of the former drugs, whilst the application of trichloracetic acid is followed by a considerable amount of after-pain, and fuming nitric acid is open to the grave objection that its action cannot be localised.

The most efficient of all methods of treatment is, however, the application of a fine galvano-cautery point at a dull-red heat, but it should only be employed by those who are thoroughly conversant with aural technique. The method has the advantage of being both rapid and thorough, whilst it is seldom followed by any after-pain or reactionary symptoms.

In conjunction with the local application of caustics, alcoholic solutions of boracic acid or perchloride of mercury should be employed.

In many cases, however, the employment of forceps or curettes is necessary. After the application of cocaine the exuberant granulations should be removed piecemeal with forceps (Hartmann's) or scraped away with sharp steel spoons (Politzer's). Following their removal the raw surface should be dried, painted with pure carbolic acid, and dusted over with boracic acid powder; or, if pain is complained of, a powder containing equal parts of boracic acid and orthoform. When the middle ear is blocked with inspissated secretion, cholesteatomatous debris, etc., it may be necessary to wash it out through the Eustachian tube.

Post-Suppurative Residua.—The amount of damage done by suppurative otitis media to the structures of the middle ear varies enormously in different cases, and the residua left with the localisation and the extent of the original morbid process. Connective tissue formations in the region of the round and oval windows, at the tympanic orifice of the Eustachian tubes and in the region of the malleo-incudal joint, produce far more damage from the point of view of audition than do changes in the membrana tympani itself, *e.g.* thickening, calcification, perforation, etc.

The various masses of connective tissue which are deposited undergo subsequent contraction or ossification, with the result that post-suppurative adhesions are formed which tend to bind the membrana tympani to the pars promontoria, the ossicles to one another or to the tympanic walls, or to obliterate the labyrinthine windows.

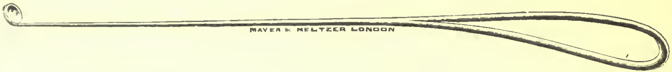

FIG. 115.—Botey's aural mirror.

The diagnosis of the site, extent, and position of these adhesions, always a matter of difficulty, and, to a certain extent, of speculation, is at times facilitated by inspection with Botey's intra-tympanic mirror (Fig. 115). By the aid of a strong light and a magnifying lens it is in some cases possible to see the actual site and extent of the adhesions or the presence of small exostoses.

The treatment of post-suppurative residua varies with the extent, age, position, and character of the pathological products. In recent cases, and when the connective tissue has not organised to any great extent, oto-massage, the injection of fibrolysin (p. 192), or the instillation into the middle ear of alkaline solutions at times affords relief.

When, on the other hand, organised and firm connective-tissue products are present, division with a knife is indicated, followed by a course of oto-massage.

Adherent Cicatrices.—When there has been an extensive perforation of the membrane, and when healing has taken place, the cicatrix may or may not become adherent to the inner tympanic wall. The extent of adhesion varies considerably, in some cases union taking place by a narrow bridge of tissue, in others the whole cicatrix becoming completely adherent. Adhesion of small cicatrices is unusual. The most frequent sites of such adhesion are the postero-superior and antero-inferior segments of the membrane. As a result of intra-tympanic adhesions the middle ear is divided into compartments, in any one of which suppuration may persist. The strength of the adhesion varies with its age and extent.

A diagnosis of adherent cicatrix is made by inspection, by inflation, or by the use of Siegle's speculum. Under ordinary circumstances the cicatrix appears as a sharply defined, oval, circular, reniform, or slit-like membrane, somewhat depressed and more translucent than the membrane immediately around. If non-adherent, it may be blown out by inflation, or drawn out by suction with Siegle's speculum. If adherent, suction produces no effect beyond a slight puckering in those places where it is not so bound down as it is in others. At times considerable areas of the cicatrix may be adherent, while other portions are non-adherent. As a result, the middle ear is divided by partitions, the epitympanic recess being frequently shut off from the tympanum proper. The amount of deafness produced is due not so much to the actual presence of the cicatrix as to the damage the original suppuration has produced. When tinnitus is troublesome, relief may at times be obtained by repeated massage and intra-tympanic inflation, the adhesions being in this way stretched and rendered more mobile. Division of adhesions by means of rectangular-shaped knives is at times possible and beneficial, the practical difficulty being, however, to prevent re-union. This may to some extent be prevented by repeated Politzerisation or catheterisation.

Treatment of Dry Perforations.—In a large proportion of cases of chronic suppurative middle-ear disease efficient treatment, or an inherent power of repair in the membrana tympani, brings about cicatrisation of the previously existing perforation. In certain cases, however, even after all suppuration has entirely ceased the perforation remains open, and the lining membrane of the cavum tympani perfectly dry and cicatricial. Such dry perforations may remain *in statu quo* for years without showing any change as regards size or situation. On the other hand, a dry perforation may be found to have healed years after all disease has become quiescent, the natural *vis medicatrix naturae* having finally asserted itself. In this way even very large defects in the membrana tympani may heal spontaneously.

In the majority of cases it is desirable to attempt to produce cicatrisation, partly because an improvement in audition is thereby frequently produced, and partly also because the mere fact that the perforation has cicatrised materially lessens the risks of recurring attacks of suppuration.

In recent perforations the edges are vascular and active, but in long-standing cases they become hard and indurated, due to the growth of epithelium from the dermic layer of the membrane over their sharply defined edges. In this way a callous, non-vascular, and inactive edge results, which, unless stimulated by artificial means, refuses to heal.

As improved hearing is by no means certain, even should closure be effected, it is desirable to differentiate between those cases in which it is likely to happen and those in which such a result is unlikely. This is ascertained beforehand by covering the perforation with a small tampon of wool or gold leaf, moistened with a drop of glycerine or paroleine, and noting if by so doing audition is improved. Improvement indicates that attempts should be made to induce cicatrisation, whilst no improvement demonstrates the existence of some form of mechanical obstruction in the region of the oval or round windows, or in the ossicular joints.

In such circumstances it is questionable whether it is worth while to make any attempt to induce cicatrisation.

The principles underlying the successful management of such cases are, first, the removal of the thickened and indurated edge of the perforation, and, secondly, its subsequent stimulation.

To effect the former the indurated epithelium covering the edge of the perforation should be painted with nitrate of silver (gr. 40, oz. 1). pure phenol, chromic acid (dr. 2, oz. 1), or a 10 per cent solution of trichloracetic acid (Okuneff). The application of trichloracetic acid is particularly beneficial, the heaped-up epithelium becoming rapidly destroyed and removed, thus exposing a vascular and active edge. Searing the margins of the perforation with a very fine galvano-caustic point is specially serviceable.

Previous to the application of the acid it is advisable to instil a few drops of Wingrave's solution of cocaine in aniline oil—aniline oil (pure anhydrous), cocaine (alkaloid), 5 per cent. An immediate effect may be the production of slight desquamation from the middle ear. This is, however, as a rule, quite easily controlled. So soon as all indurated epithelium has been got rid of, the connective tissue of the membrane produces fibroblasts and angioblasts over which the normal epithelium of the outer layer of the membrana tympani begins to sprout, and by a concentric growth the perforation becomes ultimately cicatrised. The tympanic epithelium shares also, although not to so great an extent, in this process of regeneration.

The resulting cicatrix, consisting mainly of epithelium derived from the dermic layer of the membrana tympani, although to a slight extent also from the mucosa of the cavum tympani, is always thinner than the other portions of the membrana tympani, and hence becomes slightly depressed and saucer-shaped.

The application of a small disc of salicylic acid plaster to the perforation, by setting up a certain amount of local irritation, is at times sufficient to induce healing. Radial incisions across the edge of the perforation, or complete excision of all indurated epithelium serve at times to start the process of concentric cicatrisation.

Large defects in the membrana tympani may in this way be induced to heal.

When attempts to secure cicatrisation have failed, the meatus should be kept closed by a plug of antiseptic wool, and great care taken to prevent the entrance of water whilst washing or bathing.

It must be borne in mind that the antro-tympanic epithelium in cases of long standing perforation is epidermal in character, consequently squamal collection is liable to occur, in fact a slight variety of cholesteatoma as in all cutaneous regions. Careful observation is necessary in order that epidermal accumulations may be removed and sepsis prevented.

Artificial Tampons.—In many cases of post-suppurative otitis media with persistent perforation, the application of an artificial aid to hearing affords great relief and enables the patient to enjoy the pleasures of conversation and social intercourse. The cases in which a tampon is of most value are those where the perforation is in the posterior superior segment of the membrane, and where the head of the stapes is exposed to view. The number and varieties of artificial tampons upon the market is enormous, but all are designed after the original ear-drums of Yearsley (1848) and Toynbee (1853).

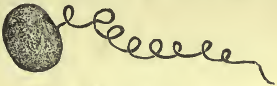
FIG. 116.—Yearsley's pad.

Yearsley's pad (Fig. 116) consists of a small ball of cotton wool, to which a thread is attached, and which may be introduced into the ear dry or moistened with some mild antiseptic.

By means of a special pair of forceps (Fig. 117) the pad is placed *in situ*, and when it has been ascertained by experiment that it is of value in improving audition the patient should be instructed as to how to introduce it.

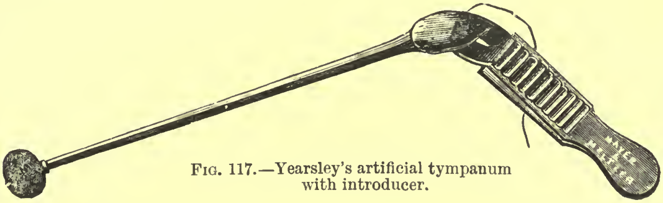
FIG. 117.—Yearsley's artificial tympanum with introducer.

Toynbee's artificial drum (Fig. 118) consists of a small disc of rubber mounted upon a silver stem, terminating in a small ring. Instead of a wire stem, which from its rigidity offers certain objections, Gruber suggested attaching a thread to the centre of the rubber disc, and introducing it either with a suitable pair of forceps or drawing the thread through a vulcanised tube so that the disc rests upon its end.

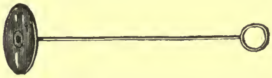
FIG. 118.—Toynbee's artificial tympanum.

To place the disc in position, the tube is introduced into the meatus and passed down until it, the disc, is felt to be in position, after which it is withdrawn, leaving the thread in the meatus.

Before introduction the disc should be cut to the proper size, and moistened with sterile vaseline or weak carbolised oil.

In the event of the pad or disc producing no immediate improvement in hearing, it should be moved from place to place, and the degree of pressure varied until either an improvement in audition is manifest, or until it is obvious that it is of no practical value.

Artificial tampons should not be employed when much suppuration exists. A small amount of fluid in the middle ear is, however, no contraindication to their use.

An artificial drum, when first introduced, should be retained *in situ* for an hour or so, the period being gradually prolonged until it can be worn all day without causing irritation. The drum should invariably be removed at night, and a fresh one introduced in the morning.

The advantages of Yearsley's pad are that it causes very little irritation, and that it is a convenient medium for the application of antiseptic remedies to the middle ear. The disadvantages of Toynbee's drum are that the rubber disc frequently becomes detached from the silver stem and gets impacted in the tympanum, and that the silver stem is prone to cause a disagreeable noise in the ear during mastication, and at times injury to the walls of the meatus.

Artificial Tampons.

To make an artificial tampon, a small piece of sterile non-absorbent cotton wool should be taken, and a thin silk ligature tied round its centre. While the ligatures are held in the left hand the wool is pulled out from either end with a pair of forceps until a small flame-shaped pad is left. The excess of wool is then cut off with a pair of scissors close to the ligatures. The tampon should then be dipped in paroleine and introduced into the ear and placed *in situ* with forceps, the ends of the ligature being left hanging from the auditory meatus. The hearing power is now carefully tested and the tampon slightly withdrawn by pulling upon the ligature until the point of maximum audition is ascertained. The ends of the silk ligature are then tied together in the form of a loop round the auricle.

Artificial Aids to Hearing.—When deafness is so pronounced that speech is not heard at a distance of more than half an inch, resort should be had to some form of artificial aid. The practical difficulty encountered is that the patient in most cases refuses to make use of an instrument sufficiently large to collect the waves of sound, his desideratum being that an instrument small enough to be accommodated in the ear and at the same time capable of transmitting vibrations, should be supplied. This, unfortunately, has so far not been found possible. The objection to such instruments as the micro-telephone, acusticon, etc., is that the secondary waves of sound are so annoying as to make them practically useless to many who might otherwise make use of them.

For ordinary purposes the palm of the hand placed behind the auricle serves as a good aid, and when speech is heard at a distance of about 2 metres it should be made use of in preference to any instrument. The ordinary conversation tube, made of special wire and covered with leather and silk or yarn, is one of the most serviceable of aids. Various forms and sizes of hearing trumpets, made of metal or vulcanite and with various-shaped beakers, have advantages in certain cases.

Much ingenuity has been expended in devising various forms of instruments which are capable of being partially concealed by particular methods of dressing the hair, arranging the hat, etc.; but speaking generally the simpler the instrument and the larger the surface for the reception of sound the greater the advantages.

The audiphone (Rhodes), constructed upon the principle that sound, when conducted to the teeth and cranial bones, is intensified, is of service to some patients, especially those suffering from nerve and post-suppurative deafness. The instrument, made of hard rubber and capable of having its curvature altered by means of a silk cord, is held in the hand and placed against the upper teeth. The waves of sound which strike its convex surface are thus directly transmitted to the cranial bones and so to the internal ear.

CHAPTER XIX

CYTOLOGICAL AND BACTERIOLOGICAL EXAMINATION OF DISCHARGES FROM THE EAR

Experience has now afforded such substantial evidence of the value of a systematic examination of all ear discharges that the writers do not hesitate to refer to such an important subject at some length.

While the technique is extremely simple, even more so than in the examination of faeces, urine, blood, etc., owing to certain degenerative and other changes in the cells, matrix, and bacteria peculiar to this region, some little experience and familiarity with their appearance is essential to successful interpretation of their respective significance.

Since information is required of cells as well as of bacteria those methods will be employed which at once rapidly and efficiently afford the desired evidence.

Collection of Material.—Whether collecting specimens for film or inoculation, careful attention should be paid to the following points:—

1. Foetor, density, and colour should be noted.
2. Secure the discharge from the nearest available spot to its origin.
3. Scrupulously avoid contamination.

With regard to *foetor*, the butyric type, which is perhaps most frequently found, is commonly associated with epidermal decomposition such as is found in ungual accumulation and smegma. It is doubtless due to changes occurring in epidermal cells in the presence of *bacillus butyricus*. In aural discharge it is unmistakable and characteristic of a desquamative process, whether meatal or antro-tympanic. That it is closely associated with putrefactive bacteria is supported by the fact that sterile cholesteatomata are free from foetor. Sometimes the foetor has the character of sulphuretted hydrogen, probably derived from the sulphur of the keratin scales. When osseous necrosis or caries exist, a phosphuretted smell is observed, especially in the presence of *bacillus proteus vulgaris.* Foetor is rare in the acute forms of aural discharge, but in the chronic it is intimately associated with *spirochaetae*, *bacillus butyricus*, *bacillus proteus vulgaris*, *streptothrix*, and various anaerobic bacteria.

Density is a feature which may afford valuable information. If serous or "watery" and continuous in flow, it is strongly suggestive of cerebro-spinal fluid, confirmed by its affording positive evidence of reducing power with deficiency or absence of proteids. If scanty and mixed with flakes, it is probably tuberculous or eczematous. In acute exudative processes it may be viscid, glairy, or coagulated, according to the nature and intensity of the infection. In chronic cases it may vary from a thin "milky" to a "creamy" or even caseous consistence. It may also be dry and "scaly."

Its *colour* may be of great variety. In all forms the discharge may be mixed with fresh blood. Should this occur in chronic cases it is strongly suggestive of active granulations and polypi; but when any haemorrhage is retained it may be "rusty" and resemble coffee or "anchovy sauce." The latter colour occurs in connection with malignant disease, while the rusty or coffee colour may be due to cerumen. Many chromogenic bacteria may be responsible for remarkable tints in chronic cases, such as the *bacillus pyocyaneus* and *micrococcus caeruleus.* Black or grey granules may be due to *aspergillosis*, but are far more frequently caused by lead, bismuth, and other salts which have been used for instillation or insufflation.

The patient should be placed in the usual position for examination alongside a good light. Guided by a speculum, the meatus being carefully cleared of accumulation, a bead of pus is removed from the region nearest to the seat of the disease by a small curette or platinum loop, taking care to avoid contact with any other surface and not to cause bleeding. The drop should be at once transferred to a clean cover-glass or slide, over which another one is placed, then lightly pressed together and separated by sliding. (If separated by *lifting*, the film will be rough or "tacky" and useless for staining.) The film should at once be dried and fixed, either by hot air (not in contact with flame) or by plunging into acid alcohol or perchloride of mercury solution, afterwards washed and dried. Should the discharge be plentiful it may be collected with a suction pipette of small calibre and then transferred to a cover-glass; but if examination is deferred, or if it is to be sent by post, its end should be sealed in the gas flame. Fixing by perchloride is really only necessary when eosin, vesuvin, or acid is used in staining. Cover-glasses are preferable to slides, being far more convenient for manipulation. At least four films should be prepared, while an extra one may be examined "wet" for motile bacteria. A culture may be taken with similar precautions, substituting a fine platinum wire for the curette. It need scarcely be accentuated that everything used should be scrupulously sterilised, and the film must on no account come in contact with a flame for fear of scorching.

Should antiseptics have been employed, it is well to suspend their use for twelve hours or more before innoculating the medium for cultivation.

As it is important that the mouth, throat, and naso-pharynx should also be carefully examined, material from the last-named region (which is normally sterile) may easily be obtained by means of a curved glass cannula (Fig. 46) which the writer devised for avoiding contamination from the mouth and fauces.

Staining.—If the staining is to be done by the aid of heat it is better to use a short wide test tube; but if cold, shallow glass dishes are more convenient than watch glasses. The simplest and most comprehensive staining processes are the following:—

1. Gram's stain:
    - (*a*) One per cent gentian aniline violet in aniline water, three minutes. Wash in water.
    - (*b*) Solution of potassium iodide and iodine, half a minute or until of a dark violet colour.
    - (*c*) Wash in alcohol until no violet comes away.
    - (*d*) Counter-stain half film in weak carbol fuchsin. Wash, dry, and mount in xylol balsam.

This is an important test, since it at once decides to which group the bacteria belong, Gram + or Gram – .

2. For tubercle, acid-fast bacilli, and squames. Carbol fuchsin and methylene blue (Loeffler), using 25 per cent sulphuric acid for decolorising, followed by alcohol. Wash, dry, and mount in xylol balsam.

3. General stain for all bacteria and cells:
    - (*a*) One per cent solution of gentian aniline violet in aniline water for three minutes and wash.
    - (*b*) One per cent methylene blue ("medicinally pure" or "monochromatic") in 0·5 per cent solution of borax ("borax blue") for three minutes, wash in water; dry and mount in xylol balsam.

These three stains are generally quite sufficient to obtain all information, yet, if No. 3 should prove too deep for the cells, use may be made of basic fuchsin (1 per cent), or carbol fuchsin, in place of the gentian aniline violet. This stains the cytoplasm a beautiful scarlet, in which the bacteria and nuclei will be well seen when counterstained with borax blue. It also demonstrates sporulation. Either method affords a most useful combination if carefully carried out, and no one who has been accustomed to work only with nuclear stains can fail to appreciate the beauties revealed by employing a protoplasmic contrast stain. It is most searching for bacteria when used in its full strength and time, but for cytology it is better when diluted 3 to 1, and with a shortened contact. Solutions must be fresh and filtered. Distilled water only should be employed.

Examination.—This should first be done with a 1 in. or $\frac{1}{2}$ in. lens, which will give a general idea of the larger cells, to be followed by a $\frac{1}{12}$ immersion lens for cytological details and bacteria.

Composition of Discharge.—A discharge usually consists of three elements: (1) cells; (2) bacteria; (3) matrix or suspending fluid.

1. *Cytology.*—The cells may be divided into two groups: (*A*) epithelial, and (*B*) mesoblastic.

(*A*) *Epithelium.*—Epithelial cells are meatal, tympanic and glandular. The commonest type is the "squame," which in the healthy state is strictly confined to the meatus, but in chronic disease invades the antro-tympanic cavity and becomes one of the most striking features of discharge from that region. They are of two distinct kinds—old and young. The old ones stain deeply with fuchsin and resist decolorising with acid. They are, in fact, acid-fast, like tubercle bacilli, their nuclei are wanting or are only indicated by a pink area ("ghosts"). Young or recently formed ones are readily decolorised with acid, and their large oval and round nuclei stain deeply with blue. There are also intermediate varieties whose cytoplasm contains keratin granules which stain violet by Gram, and whose nuclei take a faint blue.[1]

This acid-fast property of old, non-nucleated squames is one of considerable interest, since it affords not only presumptive evidence of a cholesteatomatous process involving the antro-tympanic cavity—assuming that the specimen was taken from an adjacent spot and not from the meatus—but fragments might easily be mistaken for tubercle bacilli by a careless observer. When taken from the meatus in large numbers they indicate the existence of chronic desquamation, with or without leucocytes. The blue-staining nucleated squames indicate recent or existing desquamation.

Tympanic Epithelium.—Normal tympanic epithelium is *only* seen in the early stage of acute cases. It appears as solitary or grouped spheroidal, cubical, and pyriform cells, having a pale, clear cytoplasm with a well-defined blue oval or round nucleus, often eccentrically situated. Such epithelium does not appear in chronic discharges, the tympanic lining having become transformed into the squamous or epidermal type.

Gland Epithelium.—Gland epithelium, likewise, is rarely seen, except in acute cases, and is mostly of meatal origin, since glands are scarce in the middle ear. The cells are variable in size and shape, but may be recognised by a single oval nucleus and slightly oxyphile or yellowish cytoplasm, sometimes staining deeply.

The recognition of neoplastic characters is very difficult, but whenever cells are found in closely packed groups and their nuclei are heteromitotic, they should always excite suspicion, especially when associated with myeline spheres and red blood corpuscles.

It will thus be seen that cells may be living or dead, a distinction equally applicable to the mesoblastic group and equally important, since it enables one to determine whether the cells are of recent or relatively remote origin.

(*B*) *Mesoblastic Cells.*—Mesoblastic cells may be conveniently, yet perhaps somewhat arbitrarily, divided into two groups—wandering and fixed.

The *wandering* cells are leucocytes and lymphocytes, and plasma cells. *Fixed* cells are mesothelial (endothelial and perithelial), giant cells and myelocytes. There are also many others, such as fibroblasts, angioblasts, etc., but their histological distinctions are so undecided that for the present it will be expedient to confine our attention to those whose identity and source can be readily established.

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[1] It is very important to bear in mind this acid-fast property of epithelial squames, since it may lead an inexperienced observer when searching for tubercle bacilli to think that the film is insufficiently decolorised and induce him to prolong the acid and alcohol bath until the fuchsin is either entirely removed from the tubercle bacilli or rendered so faint as to be neutralised by the methylene blue in counter-staining.

Leucocytes and *lymphocytes* are generally referred to by the comprehensive term "pus cells," but clinical cytology teaches that some discrimination is necessary, since they are unlike one another in structure, function, and significance. Whatever views may be held regarding their biological relations, their recognition and differentiation in a discharge are of no slight importance. A fresh *leucocyte* is somewhat larger than a lymphocyte, it possesses a relatively greater area of cytoplasm, which is always granular, the granules being termed oxyphile, basophile, or neutrophile, according to their selection of acid, basic, or neutral stains, a distinction of importance as blood-corpuscles, but of less value when they occur in a discharge. The nucleus occupies a relatively small part of the whole cell and may be multiple or single; the "polymorphs" are the more prominent in acute discharges, while the mononuclear are present in chronic or the later stages of acute diseases.

The leucocyte of a recent or acute exudate is very sharply defined and the nucleus stains deeply; but it soon degenerates, the outline of the cytoplasm is lost, and the nucleus either stains faintly, becomes distorted, or undergoes fragmentation into "myeline" spheres (pyknosis), which may either remain in the cloudy cell, become absorbed by another cell, or escape into the surrounding matrix, a series of changes which indicate its death. One can thus easily distinguish between the living or active and the dead or degenerated stage. As the discharge becomes chronic, large monocular leucocytes are much more numerous, a characteristic feature of granulating wounds which distinguishes it from the earlier and more exudative process. Their cytoplasm is very granular, and stains deeply with gentian violet or fuchsin, while their nuclei are paler than those of polymorphs and more irregular than those of endothelial cells, which possess a very clear cytoplasm.[1]

Each variety of leucocyte may be a phagocyte, a property which can be best demonstrated by means of the fuchsin and borax blue stain. Weak solutions and short exposure are essential since, if over-stained, the cytoplasmic granules obscure the engulfed bacteria.

The *lymphocyte* is smaller than the leucocyte, its cytoplasm is scanty, often invisible, or appearing simply as a narrow zone, which is clear when living but becomes faintly granular with degeneration. The nucleus is relatively large, single, round, and stains very deeply with borax blue or gentian violet. In acute exudative changes about one lymphocyte can be counted to twenty or thirty leucocytes, but when the discharge comes from a "granulation" source the lymphocytes are strikingly increased, sometimes being equal in number to the leucocytes.[2]

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[1] All cells in a film appear larger than when seen in section, because being soft spheres they are more or less flattened in the act of preparation by pressure, however slight.

[2] It must not be forgotten that lymphocytes are much more numerous in infants' than in adults' blood. They are consequently, therefore, often relatively more numerous in the acute suppuration of children. Whether lymphocytes of a discharge are derived from the blood or from the lymph is a debatable point. According to Maximow they may be derived from the lymphoid cells of bone-marrow, and, growing larger, may become phagocytes. Lymphocytes are also said to become plasma cells in chronic inflammatory processes. Like leucocytes, their nuclei, when old, become paler in staining power.

Thus the presence and proportion of these cells afford reliable evidence of the existence of granulation tissue and the nature of the pus-producing process. They possess little, if any, power of phagocytosis.

Mesothelial or Epithelioid Cells.—Of the *fixed* cells epithelioid elements are those most frequently found. The name mesothelium includes enthothelial and perithelial elements, since in a discharge it is impossible and immaterial to distinguish one from the other. They are derived from the lining of blood and lymph channels, also from the perivascular spaces of arterioles. They play a prominent and important part in all granulomatous formations, especially that of tubercle, lupus, and lymphadenoma, since the greater part of a typical tubercle is composed of them. They are recognised by their large size (nearly twice that of a leucocyte), irregularity in shape, large pale oval nucleus and an extensive clear cytoplasm, which on degeneration becomes granular or cloudy. Athough sometimes seen in acute inflammation, their presence in large numbers in a chronic discharge is strongly suggestive of tuberculosis. They are usually credited with being "cell eaters," but may sometimes contain bacteria; they are, however, less phagocytic than leucocytes, although nuclear fragments of other cells are often seen inside them. It is probably from these cells that "giant" and "syncitial" cells are formed, either by nuclear division or fusion.

Myelocytes.—Several kinds of myelocytes are seen in aural discharges, but they may be conveniently divided into two classes, viz. small mononucleated and large multinucleated. The first variety is difficult to distinguish from a large lymphocyte or leucocyte; it is, however, somewhat larger, its cytoplasm is clear and more extensive, while the nucleus is single, round, eccentrically situated and larger than that of a lymphocyte. The multinucleated has two or more closely packed nuclei and the cell is two or three times larger than the mononucleated. They are both derived from the red marrow and endosteum, and may sometimes be seen in both acute and chronic inflammation of diploic bone. In cases of primary acute osteo-myelitis they are sometimes very numerous, in chronic forms much fewer, the small variety being a striking feature in acute osteomyelitis, while the large multinucleated form occurs chiefly in slower osteoporotic processes, when it is referred to as an osteoclast. In the course of acute infection the thin cytoplasm may contain neutrophile granules.

Erythroblasts.—A much smaller form (erythroblast), whose cytoplasm stains brilliantly with eosin, is not uncommonly found in acute osteomyelitis of infants.

"*Giant Cells*" differ from multinucleated myelocytes and syncitial cells by the arrangement of their nuclei, which are generally oval, more numerous and grouped symmetrically round the periphery of the cell, while the nuclei of myelocytes and syncitial cells are generally round, fewer in number and crowded together in the centre. They are rarely met with in discharge unless the tuberculous process is in a state of acute exacerbation and rapidly breaking down owing to a supplemental infection. In scrapings taken directly from the diseased spot and ground up with normal saline solution, they constitute a striking feature in the film when stained with thionin and eosin.

Multinucleated or giant cells are present in many conditions which are not tubercular. They are sometimes termed syncitial cells, and are the products of irritation. They are probably also derived from epithelioid cells, and are often seen in sections of non-specific granulomata.

Plasma Cells.—Plasma cells are recognised by their strong affinity for pyronin. They occur only in chronic inflammation, and are said to be derived from either lymphocytes or endothelium.

The widely varying conditions, to which an ear discharge is subject, necessitate a short reference to certain significant changes which are met with in the leucocyte.

As a result of retention the leucocyte loses its sharp outline very soon after its exit from the blood stream. It also loses its phagocytic power. The cytoplasm becomes granular and fatty, the nucleus swollen, fragmented, and less receptive to basic stains.

Such changes are said to be due to the formation of trypsins from cell degeneration, which not only neutralise the phagocytic power of the living leucocyte but also dissolve living tissues.

Bacteria.—There are perhaps few organs which present a greater variety of bacteria in their discharge than does the ear, particularly in the chronic forms of disease. In acute stages, while the total number of micro-organisms present may be large, the varieties are generally few as in other regions.

Discharges may be examined for bacteria in three ways: by direct or wet examination, by means of specially stained films, and by cultivation on agar, serum, gelatine, bouillon, and other media.

The evidence afforded by films or smears alone, if properly prepared, is of considerable diagnostic value in spite of the occasional difficulty in accepting the identity of a micro-organism solely upon its morphological and staining features, but a culture is indispensable.

Cultivations alone should not be relied upon, since they may afford but partial evidence of the bacteria present, and films, if stained by three methods may often reveal important bacteria which fail to grow on the selected medium.

Chronic Discharge.—The following bacteria were specially recorded in the course of over 1000 examinations of chronic discharges. It is by no means exhaustive, since it does not include every bacterial form which was present, but is fairly representative of those bacteria whose identity was provisionally established, and whose frequent occurrence, together with certain clinical and pathological associations, imparts to them a varying measure of interest. They are as far as possible arranged in order of relative frequency, the sign + or – indicating a positive or negative reaction to Gram's stain:—

Staphylococcus (*albus* and *aureus*)	+
Diplococcus catarrhalis	−
Bacillus proteus vulgaris	−
Bacillus subtilis	+
Bacillus pyogenes foetidus	−
Bacillus butyricus	+
Torulae, yeasts, etc.	+
Leptothrix	+
Bacillus fusiformis	−
Spirochaeta refringens (*Spirochaeta foetida*)	−
Streptococcus	+
Bacillus mesentericus vulgatus	−
Bacillus coli communis	−
Bacillus pyocyaneus	−
Bacillus tuberculosis	+
Micrococcus tetragonus	+
Bacillus of influenza (Pfeiffer)	−
Streptothrix	+
Pneumococcus	+
Penicillium glaucum	−
Aspergillus niger	−

Acute Discharge.—A film from an acute discharge may show but few micro-organisms, yet, although sometimes containing a large number, the varieties are few in comparison with those seen in chronic forms.

Unlike chronic cases, too, a very large proportion are intracellular, phagocytosis being often a striking feature (*v.* page 200).

An arbitrary division of bacteria into pathogenic and non-pathogenic varieties is attended with many difficulties in the case of the ear, since potentiality for serious mischief in this organ which so many reputed saprophytes possess renders such a classification one of doubtful expediency. They will, therefore, be dealt with in groups, which possess some special interest irrespective of any orthodox or arbitrary division.

Acid-fast Bacteria.—Ear discharges are particularly rich in a variety known as *acid-fast*, a term which is applied to those bacilli which retain their stain (basic fuchsin) after washing in sulphuric acid. By further treatment with alcohol, they all give up this stain to a greater or less extent, with the exception of tubercle and leprosy bacilli, which are therefore alcohol- as well as acid-fast. They are not "colour true."

Although this acid-fast property was at one time believed to be monopolised by tubercle, it is now recognised that a very large number of bacteria also possess it; but since many of them do not equally and constantly respond to the alcohol distinction, they thus possess a technical interest which is in some of them perhaps disproportionate to their clinical importance. Morphologically they fall into three distinct groups:—(1) Rod forms, (2) streptothricial, and (3) clostridial.

The first group embraces many bacilli which possess some morphological resemblance to tubercle bacilli, but are much more readily decolourised by either a longer exposure to acid or by alcohol—features which are characteristic of the smegma type of bacillus. They vary from 2·5 μ to 4 μ in length, and occur in very numerous "clumps" or groups. Each cluster is, however, composed of far greater numbers than that which an ordinary tubercle group presents. They stain more evenly, are not beaded, and are definitely Gram negative. They occur in company with the *bacillus butyricus*, acid-fast squames, and are generally attended with considerable foetor. In this group should be included the *bacillus subtilis*, which, although not recognised as an acid-fast organism, does sometimes exhibit that property in chronic aural discharges. It is easily recognised, being much thicker and often longer than the tubercle bacillus. Further, it has a well-marked equatorial endospore and often occurs in chains. The endospore generally retains the fuchsin after an acid bath, but yields it after prolonged exposure to alcohol.

There are often many short bacillary forms which may show a slight acid-fast property should the acid bath exposure have been too short; but they can be easily differentiated in other parts of the field by their selection of the blue stain, *i.e.* they are not "colour true."

Streptothricial forms are recognised by their characteristic grouping in the shape of closely packed "felted" masses of branched filaments. But when solitary or in short segments their beaded appearance strongly resembles tubercle bacilli. They are, however, more slender, and, although often Gram positive, are readily decolourised by alcohol. There are also many streptothrices which are not acid-fast, but all are botanically allied to the tubercle bacillus.

Clostridia are easily recognised by the presence of a large, deeply staining, equatorial spore. This bacillus is somewhat short, thick, swollen in the centre, and more readily yields its fuchsin to alcohol than any of the others. This is an important group, since it includes the *bacillus butyricus*, which is one of the micro-organisms responsible for the production of butyric acid, so closely associated with the acid-fast property and with foetor.

In addition to the foregoing there are many other forms of bacilli which may assume an acid-fast property in the ear, but such a power does not seem to be possessed by any coccal form. Apart from their differential diagnosis from tubercle, acid-fast bacteria are chiefly of interest from their frequency and number, and from what is known of streptothricial infection of other organs the association of this micro-organism with aural discharge is not without significance.

What is the explanation of this acid-fast property?

After many failures to cultivate acid-fast bacilli aerobically the writer felt that they might possibly be anaerobes, for it was pointed out by Pasteur, and in a recent article by Rist, that putrefactive changes in septic otitis were chiefly due to anaerobic bacteria. However, upon exposing films of bacteria (cultivated from ear discharge) to butyric acid, it was found that several forms acquired acid-fast qualities in degrees which varied with the duration of exposure to the acid. As

San Felici had found that certain bacilli could be rendered acid-fast by cultivation in butter and lard, butyric acid was added to the culture media and after several attempts bacilli were obtained which possessed acid-fast property in varying degrees. Butyric acid was selected from the striking resemblance which its odour bears to that of foetid aural discharge, a feature which was emphasised by the smell of a bottle of cerumen and meatal accumulations which had been collected for experimental work.

A case was recently reported by Rolleston and Higgs in which a diagnosis of tuberculosis was based to a certain extent upon the presence of acid-fast bacilli in the sputum, but which was proved by the necropsy to be one of typical squamous epithelioma of the stomach. The bacilli upon which the diagnosis was made were subsequently found in groups on the surface of the growth and in the substance of sections. Individually they were unusually long, not beaded, and resisted decolorisation by alcohol for two hours. Cultivation attempts were unsuccessful. The case is interesting by reason of the association of acid-fast bacilli with squames undergoing keratinoid changes, and also by their occurrence in a region rich in butyric acid, conditions which are well marked in chronic aural discharges.

It has been suggested that cerin is the substance responsible for the acid-fast property. However that may be in the ear, it cannot hold good in the stomach, skin, lungs, cysts, etc., where cerin does not occur. The writer's experience so far indicates that there are two distinct kinds of acid-fast bacilli—those which are so *naturally* and those which become so *artificially*, or at all events as a result of their environment. The acid-fast property of the tubercle bacillus and the dead squamous epithelium of cysts and cholesteatomata is essentially intrinsic, while that of the bacteria under consideration is most likely fortuitous or extrinsic. Although endospores are often strongly acid-fast, it is interesting to note that coccal forms, *e.g.* staphylococci, streptococci, diplococci, etc., never exhibit such a property naturally or artificially, even after prolonged exposure to butyric acid.

In attempting to explain the nature of this property the leading features may thus be summarised :—

1. Acid-fast bacteria are present in putrefactive conditions which are attended by the presence of butyric acid, *e.g.* ear, stomach, intestines, skin, etc., and also in butter and cheese.
2. The acid-fast characters may be produced artificially by butyric acid.
3. Acid-fast bacteria are generally associated with the presence of squames and possess a distinct and characteristic foetor.

The next group, important both clinically and histologically, consists of four diplococci : (1) *Diplococcus catarrhalis* ; (2) *pneumococcus* (Fraenkel) ; (3) *meningococcus* ; (4) *gonococcus.*

Perhaps around no other group of bacteria has there been such a conflict of opinion, both clinical and pathological. On the one hand we are told that 60 per cent of healthy people carry pneumococci in their throats, and experience teaches that that micro-organism is not only responsible for serious aural troubles, but also for meningitis. It should, therefore, be considered a conditional parasite, and, although apparently harmless in the mouth, of serious import if found in the ear.

It must not be supposed for one moment that it is possible to unequivocally identify a specific diplococcus in a film preparation taken straight from a discharge; such evidence must only be considered as *presumptive*; a *positive* diagnosis requires confirmation by culture in artificial media, under the most precise bacteriological routine. Still, notwithstanding their great mutability in size and shape, evidence of no small value is obtainable by simple and rapid methods.

The film should first be stained by Gram's method, and if *positive* it is probably a *pneumococcus*, since the other three are Gram negative. Should it be capsulated, oval, or lanceolate, like two candle flames placed base to base, it is presumably the *pneumococcus* of Fraenkel. Too much importance must not be attached to its size nor upon the fact that it may be arranged in short chains of pairs (torula chains), since *staphylococci* and *streptococci* may appear as pairs also.

The *pneumococcus* is not easy to grow, the best medium being blood-agar at 37° C., when it appears as minute, discrete, translucent "dew-drops," very slightly elevated. The colonies are accompanied by a marked change in colour of the surface medium, shown by a transformation of the oxy- into met-haemoglobin, a property described by Eyre as a pathognomonic feature. Further, it produces an acid reaction with dextrose, lactose, levulose, galactose, and maltose. It will not grow on gelatine at 20° C., and when artificially grown has no capsule and is often moniliform.

The remaining diplococci are Gram –, but the commonest of all is the *diplococcus catarrhalis*. It is by far the largest, and occurs as a well-defined spherical diplococcus except when dividing, it being then "chestnut-shaped." It is not usually encapsuled, but often occurs in chains. It will grow on almost any medium, especially on gelatine at 20° C.; in fact, it is the only Gram – diplococcus which does so. Finally it produces an acid fermentation with all the sugar media, and grows well on nasgar at 25° C.

The writer's experience shows that Gram + diplococci are of much less frequent occurrence than Gram –, not only in acute, but also in chronic inflammation and in operation wounds of the ear.

Should the diplococcus not grow on gelatine and be Gram –, it is either *meningococcus* or *gonococcus*. Morphologically the *meningococcus* is generally very small, but in cultures may assume a large size. When young like other cocci it is facetted or "chestnut-shaped"; older forms are spherical. It is not encapsuled. It selects carbol thionin readily, while its occasional intra-cellular position is not peculiar. The best medium for its culture is nasgar at 37° C., on which it grows as smooth, translucent, circular discs, and is the only Gram – diplococcus to do so. It causes acid fermentation with all saccharine media except sucrose.

Whether this is the micro-organism responsible for epidemic cerebrospinal meningitis there still seems some doubt.

The *gonococcus* is almost persistently facetted, reniform, or chestnut-shaped. Its intra-cellular character is marked by four or more occurring in every fourth leucocyte. In size it is smaller than *micrococcus catarrhalis*, but generally larger than *pneumococcus* and *meningococcus.* Stained readily by Pappenheim's solution it strikingly selects pyronin. It grows on blood-agar and nasgar, the latter at 22° C. Finally it causes acid fermentation with glucose and galactose only.

While fully realising the difficulties in the identification of any micro-organism, especially in the case of a diplococcus, it is not too much to say that a reasonably reliable and presumptive diagnosis may be obtained from the morphological evidence of a well-stained film. Confirmatory evidence by culture, however, must always be employed in the event of serum or vaccine treatment being entertained. Much assistance may be afforded by attention to the following points:—

1. Carefully note the Gram reaction.
2. A chain of moniliform grouping is not necessarily streptococcal.
3. That encapsulation is not always a reliable distinction, and that any variety may be intra-cellular.
4. That too much reliance must not be placed upon the size and shape of individual diplococci, since great variation occurs in the life-history of each type.
5. That it is better to be guided by average rather than by solitary examples, to remember that every diplococcal form in the ear should be regarded with suspicion, and that the smaller it is the more serious its significance.

Spirochaetae, although familiar in the throat and other situations, have not hitherto been identified as attendants of aural lesions; and it is only lately that the writer has established their frequency.

Spiral forms similar to, if not identical with, *spirochaeta refringens* (*spirochaeta buccae*, *spirochaeta dentium*), occur in large numbers in chronic and occasionally in acute discharges from the middle ear, invariably accompanied by spindle-shaped bodies known as *bacillus fusiformis* (*bacillus hastilis*, bacillus of Vincent, etc.). They are not readily seen in thick discharges unless deeply stained, being either hidden by the matrix granules or fail to be rendered visible from their weak affinity for ordinary stains. They can be readily demonstrated by the following simple method: After fixing by heat or alcohol the film is placed for ten minutes in a 1 per cent solution of gentian aniline violet. It is then washed in water and passed through Gram's iodine solution for one minute, again washed in water, and examined. Azure blue and Giemsa's solution demonstrate both forms, but these stains are very expensive and not so reliable as the first method, which is an ordinary Gram without the alcohol bath, this being contra-indicated owing to both bodies having a Gram negative reaction.

These bodies are nearly always associated with a peculiar foetor differing somewhat from the butyric smell, being more like that of strong

Roquefort cheese, a peculiarity which was specially noticeable in pus from cerebral abscesses, which contained them in large numbers.

The *spiral* form varies considerably in size and shape. Usually it is long, slender, and undulating, with from four to six coarse unequal curves, and pointed at each end. When blunt it is probably due to fracture. Not infrequently, especially in a dense matrix, it may be straight, looped, curved or coiled. It is apparently homogeneous throughout, of a lavender or pale bluish colour when small, but when larger and thicker it stains more deeply. In thin films they may be seen even unstained by reason of their refractile property. They occur singly or in thick felted masses. Compared with the rigid corkscrew curls of the *spirochaeta pallida* this spirochaeta more resembles an eel or a whip-lash, having coarser, fewer and less regular turns. It is not segmented like the *spirochaeta sputigenus* of Miller or the comma "bacillus" of Koch, but is evidently an undulating form of a straight filament, and its variation in shape depends upon its age, the density of the medium, and the form it possessed at the moment of fixation. The *fusiform* body is also Gram negative, but as a rule takes basic stains more readily than the spirals, and is always a more prominent feature in films. It also varies in size and shape, being from 5 μ to 25 μ in length by 1 μ to 3 μ in thickness at its centre, from which it tapers to each extremity. It occurs singly or in pairs "end to end," and is often marked by two or more darkly staining granules with a clear interval near the equator. Occasionally shorter and blunted forms may be seen, but it can scarcely be said to resemble a bacillus. Not infrequently it is bent like a "boomerang."

Neither form is easily grown aerobically; small fusiform bodies may be, however, cultivated by deep stab inoculation in agar, but not the spiral form. Both, however, have been grown anaerobically on ascitic agar by Tunnicliffe, the fusiform bodies appearing on the second or third day followed by spirals on the fifth.

From the fact that these two bodies are almost inseparable companions, that intermediate forms can be seen in films and their transition apparently traced, it is reasonable to assume that they represent phases in the life-history of one organism. They are evidently not bacilli, and although occurring as saprophytes in connection with decomposition processes in many parts of the body, in view of the fact that they are to be found in large numbers, not only in the mastoid antrum, but also in cerebral and cerebellar abscesses, such an association affords strong presumptive evidence of their possessing a pathogenicity not quite in harmony with their saprophytic reputation.

In many cases, too, of chronic disease of the nasal accessory sinuses they are the predominant micro-organism. Their occurrence in pyorrhoea alveolaris is well known. They are present in about 30 per cent of aural discharges of the chronic foetid type, and often afford such a striking feature in the film as to suggest that it must have been taken from the mouth. They have been found in hospital gangrene, acute and chronic forms of tonsillitis, Vincent's angina, noma, vaccine pustules, cancer, smegma, balanitis, vaginitis, venereal warts, etc. The *spirochaeta pallida* of Schaudinn the writer has not yet seen in aural discharge.

They are easily demonstrated in wet films by the dark ground illumination, it being only necessary to dilute the discharge with an equal volume of distilled water or normal saline solution.

Leptothricial forms are frequently associated with the foregoing spirals, in company with torulae, yeasts, etc., which are generally grouped as "throat" organisms. They are specially numerous in the profuse non-purulent discharge referred to later.

Streptococci.—Many varieties of *streptococci* are described, but in aural discharge they may be considered under two types: the *longus* (*streptococcus pyogenes*), which occurs in long chains; *streptococcus brevis*, which occurs in short chains. The *streptococcus longus* is held to be the pathogenic form, while the *streptococcus brevis*, which is commonly found in the mouth and throat, is said to be without pathogenic properties.[1] They are both Gram +. The individual cocci are somewhat larger than the staphylococcus, they often appear diplococcal when in chains, but their Gram reaction affords a reliable differentiation.

There is a minute variety, the *streptococcus conglomeratus*, which, though not common in ear discharges, is by no means rare in acute tonsillar affections, and should therefore be looked for in acute suppuration of the middle ear, since it is said to possess considerable virulence.

A *streptococcus mucosus* has recently been described by Schottmüller as responsible for a large proportion of cases of acute suppuration of the middle ear. It is said to occur in short chains like *streptococcus brevis*, but composed of diplococcal elements enclosed in a delicate capsule which can be demonstrated by the acid thionin stain. Like other streptococci and pneumococci it is Gram +, but differs from the latter in its shape.

Staphylococci are easily recognised by their grouping. They are Gram + and smaller than streptococci, but whether *aureus*, *albus*, or *cereus* cultivation alone can decide. Their pyogenic powers are fully established, and they are the most easily grown of all the pathogenic bacteria.

The *bacillus proteus vulgaris* is of interest chiefly from its frequent occurrence in chronic discharges, being present in quite 50 per cent of examinations. Like the colon bacillus it stains with difficulty unless previously treated with iodine or potassium permanganate. It is Gram – and about 3 μ in length (with a central constriction), but may grow into long leptothricial threads. It is nearly always associated with foetor, and has the reputation of being a powerful ptomaine producer.

The *bacillus subtilis* is very common and one of the largest bacilli found in the ear, being from 4 μ to 6 μ in length. It is easily recognised by its size and spore so well differentiated by the fuchsin and borax blue stain. It is Gram + and occasionally exhibits the acid-fast property. It is also associated with foetor.

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[1] Marmorek, however, holds that length of chain is variable, and Widal has shown that the non-pathogenic forms from the mouth, when cultivated with *bacillus coli communis*, become pathogenic.

Streptothricial forms are not uncommon, and have already been referred to under the acid-fast group; most of them, however, do not possess this property, which is most probably fortuitous. They are all Gram + and also Neisser +, and can be recognised by their peculiar grouping as felted masses of thin, beaded, and often branching filaments, showing irregular staining. The characteristic clubs of *actinomyces bovi* are not seen.

The *bacillus of influenza* (Pfeiffer) has the reputation of playing an important part not only in acute exacerbations of middle-ear suppuration but also in primary attacks—an association first demonstrated by Pfeiffer himself. Owing to its feeble staining reaction it is easily overlooked, but if treated with gentian aniline violet and iodine it is readily seen in acute cases, especially those complicated by osteo-myelitis. It appears in irregular groups or "flocks" of minute straight bacilli about 1·5 μ in length, sometimes in pairs but never in chains. It is Gram – and strongly selective of fuchsin. In several acute cases the writer has found the Gram – *bacillus capsulatus mucosus.*

The subject of bacteria must not be dismissed without reference to torulae. They are by no means uncommon in chronic cases, but are probably of but slight pathogenic importance. They can be easily distinguished from cocci by their large size. Although spherical when fully developed they often appear like "double chestnut," or in chains. The writer recently examined a case of acute discharge with a large perforation (about the twenty-first day) in which they were present in large numbers without any other bacteria. The patient, a youth, was also the subject of tonsillitis and naso-pharyngeal trouble, his throat being infested by the same micro-organism which was shewn in both films and cultures.

Matrix.—Chemically and microscopically the *matrix*, or fluid part of a discharge, varies considerably according to its origin. In acute cases at first it is usually clear or slightly opaque and contains mucin and globulin. Mucin predominates in the catarrhal type and is converted into a thread-like readily staining film by alcohol, but is precipitated as minute granules if fixed by acetic acid. Globulin, when heated or fixed by alcohol, becomes stringy. In acute membranous or plastic exudates fibrin is formed spontaneously from fibrinogen in the form of regular interlacing filaments, which stain deeply by gentian violet.

In chronic as well as in the later stages of acute cases the matrix is generally opaque, owing to granules of various size and shape, which stain readily and obscure the cells. The smallest are derived from degenerated cytoplasm, while the larger and more deeply staining particles are nuclear derivatives. Others may be from broken-down bacteria and paranuclei.

When squamous epithelium is present the minute particles are very numerous, being probably keratin granules, and stain deeply with Gram's reagent. Mixed with them are highly refractile fat spheres selecting osmic acid and sudan iii., which give to the leucocyte the name "sudanophile."

Cholesterin crystals (cholesterol), in the shape of flat rhombic plates and feathery crystals of fatty acids, are characteristic of old desquamative changes as in cholesteatomata. Bone particles are easily recognised by their hard grittiness and by the breaking of cover-glasses in preparing the film, but are by no means common. Cerein is recognised by its bright yellow spheres or masses in unstained films, and by its selection of fuchsin and eosin when stained. The more acute the process the clearer the matrix, while the older and more chronic the discharge the more opaque and granular is the film.

In some primarily acute and acute secondary exacerbations, coarse spirals similar to Curschmann's in asthma are occasionally seen. Although smaller than those occurring in sputum they conform to the classical description in possessing a deeply staining core, surrounded by a pale transparent envelope.

Summary.—Acute discharge from the middle ear in a mild (catarrhal) form is characterised by sharply defined leucocytes (polymorphic) and very few lymphocytes, tympanic epithelium, singly or in clusters. A Gram – diplococcus (*micrococcus catarrhalis*) most frequently occurs, occasionally associated with mouth organisms such as spirochaetae and torulae.

In the severe or suppurative type leucocytes and erythrocytes predominate at first with a few lymphocytes. Later the erythrocytes disappear, while large mononuclear leucocytes become well marked on about the third or fourth day. Phagocytes are usually well marked during the first two or three days. Tympanic epithelium occurs early, but disappears until healing commences. The cytoplasm of the leucocyte becomes granular and ill defined, while the nucleus stains faintly and is distorted and fragmented towards the second week. In infants lymphocytes are much more numerous than in adults.

Many bacteria are found in acute discharges, including "throat organisms," but the more prominent are *diplococcus catarrhalis*, *diplococcus pneumoniae*, *streptococcus brevis* and *longus*.

Acute external otitis may occur in several degrees from an acute desquamative process involving the superficial structures only, characterised by nucleated squames, gland epithelium, and leucocytes, to abscess or purulent cellulitis involving the deep structures, when leucocytes and lymphocytes will be abundant, accompanied by streptococci, diplococci, staphylococci, and also rarely gonococci.

When the disease assumes a chronic form the discharge is "watery," lymphocytes and leucocytes being few or wanting. Epithelial squames are plentiful, and among many varieties of bacteria the *penicillium glaucum* is prominent.

The conditions responsible for chronic discharge from the middle ear—comprehensively termed chronic suppuration of the middle ear—are so varied that pathological accuracy demands some differentiation. As most frequently happens "granulation tissue" is responsible for the pus. Evidence of this is afforded by the presence of leucocytes of all kinds, large, small, mono- and polynuclear, normal and degenerated, but especially by *lymphocytes*, which are very numerous, while epithelial cells are not uncommon. Bone disease may be marked by myelocytes or osteoblasts.

Cholesteatoma is indicated by the presence of closely packed acid-fast squames with or without bacteria, a distinction which may appear to be unnecessary, but is really one of great importance, especially when the cells are of antral source, for a septic cholesteatoma in that situation affords a stronger reason for radical measures than a non-septic one—an interpretation which is amply supported by examination of antral contents removed by operation.[1]

Among the many varieties of chronic discharge experience teaches that there is one which deserves special attention. It is generally very profuse, intermittent, extremely foetid, opaque, and of the consistence of cream. On examination it is found to be entirely free from cells, either epithelial or leucocytic, but consists entirely of throat organisms in an albuminous matrix. Strictly speaking it is therefore not true pus, but merely a polymicrobic emulsion. It appears as if the imperfectly drained and ventilated antro-tympanic cavity had assumed the rôle of a cultivating chamber or "septic tank" containing bouillon in which different families of bacteria abundantly flourished.

With such a discharge, whose most striking feature is the large number of spiral and fusiform bodies with practically no leucocytes or lymphocytes, the existence of an active granulation surface may unhesitatingly be excluded. There is a passive yet highly septic cavity which calls not only for active aural measures, but also for attention to the original source of infection. It is the differentiation and identification of such a condition as this that will fully repay the extra trouble of a microscopical examination of the discharge. Such cases further illustrate the necessity for a bacteriological examination of the naso-pharynx, which in healthy subjects is sterile, but is invariably septic in all acute and chronic infections of the antro-tympanic cavity.

By the term "throat organisms" is meant a group of bacteria which are nearly always to be found in the mouth and faucial area, either in health or disease, but do not occur in the healthy ear. It includes *spirochaeta foetida*, *bacillus fusiformis*, *leptothrix*, *bacillus subtilis*, *bacillus proteus vulgaris*, *penicillium glaucum*, together with a large variety of moulds and yeasts which may be potentially pathogenic, but for the time are leading a saprophytic existence in the throat.

In this group of cases, which is by no means a small one, a highly septic state of the mouth, fauces, or nasal cavities invariably co-exists, the commonest form being pyorrhoea alveolaris and chronic lacunar tonsillitis—affections which are probably not only responsible for the original infection, but also for repeated renewals of the aural trouble.

It is important to note that in *acute exacerbations* of the chronic suppurative form the discharge somewhat resembles the primary acute. Freshly exuded leucocytes prevail with a diplococcus, Pfeiffer's bacilli or streptococci. Lymphocytes are often numerous, and myelocytes may be seen should there be any bone complication. In the course of a few days mononucleated leucocytes become plentiful, with a few more lymphocytes and nucleated squames.

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[1] While examining antral contents removed by the mastoid operation several specimens of infection by mycelial threads have been met with, the squames being mixed with a beautiful labyrinth of straight, tortuous, and often branching filaments of three distinct types—leptothricial, streptothricial, and mycelial.

In acute tuberculous examples of this group there will also be present the specific bacilli. But tuberculous discharge, when *chronic*, is of a very distinct type. It is thin or watery in character, with white granules or flakes. Lymphocytes are plentiful, with large epithelioid and even "giant cells." Leucocytes are far less numerous than in non-tuberculous forms, except during an *acute* attack due to supplementary infection, when the discharge is much denser and distinctly purulent in type. The presence of plasma cells, minute amorphous granules, and "bone grit" is also a marked feature of tuberculous discharge. Giant cells are rare unless the specimen be taken directly from its source. As in tuberculous sputum, *micrococcus tetragonus* is a frequent attendant. When the process is mixed, as usually happens, many varieties of bacteria will be present and attended by marked foetor.

In *acute osteo-myelitis*, the discharge contains, in addition to leucocytes and lymphocytes, considerable numbers of large mono- and multi-nucleated myelocytes, which are easily distinguished by their size, shape, nuclei, and staining. There may be many bacteria present, but few varieties, diplococci and streptococci predominating.

Chronic desquamative external otitis may be either moist or dry. In the former many bacteria are present, with but few leucocytes and many squames, old and new. The commonest bacteria are staphylococci, *bacillus butyricus*, *bacillus proteus vulgaris*, mycelia, and torulae. In the dry form only scales occur with *aspergillus niger*, *penicillium glaucum*, *bacillus butyricus*, and *bacillus proteus vulgaris*. In every form acid-fast squames are a very prominent feature.

Haematology in Aural Disease.—Examination of the blood is especially of value in diseases of the ear when attended by complications.

It should always be complete; yet the most valuable evidence is afforded by an estimation of the number of the white corpuscles, a marked degree of leucocytosis, *i.e.* from 20,000 to 100,000 per c.mm., being unequivocal evidence of a suppurative process, and strongly presumptive of its being locked up, *e.g.* intra-cranial. In addition to the *total* count a *differential* count should always be made, since the presence of an excess of mononuclear cells is strongly suggestive of "focal" suppuration.

With regard to bacteria, the evidence afforded by an examination of the blood is not often of immediate positive value, yet the presence or absence of organisms should always be sought for either by means of films or cultures.

For the differential count and for cytological evidence films should be stained by Wright's or Jenner's solution. When bacteria are being looked for Gram's method, supplemented by thionin, is the most useful stain. In the case of Gram's stain somewhat thicker films may be used with advantage, and should be fixed in a saturated watery solution of bichloride of mercury. Normally the differential count of leucocytes shows—

Polymorphs	60 to 70 per cent.
Mononuclears	3 to 5 ,,
Lymphocytes	20 to 30 ,,
Eosinophiles	1 to 4 ,,

In cases of suppuration, especially when deeply seated or when locked up, white corpuscles may vary from 30,000 to 100,000 per c.mm. In such cases the percentage of mononuclear leucocytes is distinctly increased, being sometimes as high as 20 per cent of the differential count.

Iodinophiles and sudanophiles are also often found in small numbers, while eosinophiles are usually scanty, especially in cases of purulent meningitis.

In tuberculosis without pyogenic infection leucopenia or diminution of the total leucocyte count is often found.

Iodinophiles are demonstrated by staining the blood film with equal parts of Gram's iodine solution and mucilage of acacia for half an hour. Sudanophiles (fat-holding cells) are stained with a 0·2 per cent solution of sudan iii. in alcohol after fixing in bichloride of mercury solution. Both types of cell are characteristic of locked-up degenerated pus cells such as occur in cases of long-standing cerebral abscess. Neither type of cell is found in acute cases.

The red corpuscles exhibit but slight variation except in cases of profound septicaemia, when they may be reduced in number to 3,000,000 per c.mm. The most marked and important phenomenon in such a condition is the low "colour-index." This evidence of corpuscular poverty in haemoglobin should always be sought for, and is of much significance.

The evidence of phagocytosis is of considerable value, since it is an important guide for vaccine treatment. It may be demonstrated by staining thin films with Wright's and Pappenheim's stain or with carbothionin solution (0·5 per cent) after fixing in bichloride of mercury.

CHAPTER XX

AURAL POLYPI

Aural Polypi.—Connective-tissue growths of a pendulous or polypoid shape are frequently met with in the course of chronic suppurative otitis media, much more rarely in acute infections of the middle ear, and in inflammatory conditions of the external auditory meatus due as a rule to suppuration of the mastoid cells. They are more frequently found in males than in females and in children than in adults. They present great variations in size, colour, form, and consistence. Most frequently they arise from the mucosa covering the inner and inferior walls of the tympanic cavity and the surface of a perforated membrana tympani, more particularly its free edges. They also not infrequently arise from the mucosa enveloping the ossicula auditus, from Prussak's space, from the depths of the epitympanum or antrum, and even from granulation tissue on an exposed sigmoid sinus. In rare cases they have been found springing from the mucosa of the Eustachian tube and mastoid cells. As a rule they are sessile, arising from a single pedicle. One or more polypi may be found in the ear at one and the same time having distinct and separate pedicles, while two or more having separate pedicles may in course of time become cemented together as the result of inflammatory adhesion.

In exceptional cases a polypus may become adherent to the walls of the meatus and even produce its complete stenosis. When arising in the auditory meatus they grow as a rule from its posterior superior wall in the immediate neighbourhood of the membrana tympani, or from the outer surface of the membrane itself. Their origin may be from the deeper layer of the cutis, or from the periosteum.

In size they vary considerably, at times being quite minute, at other times filling up the whole auditory meatus and even projecting beyond it. Generally speaking, the size and age of the growth bear a definite relationship to one another. Thus the longer the growth has existed the larger it is.

Polypi have usually an elongated pyriform shape, so far at least as that portion of the growth superficial to the membrana tympani is concerned. When originating in the tympanum their form is irregularly hour-glass shaped, the constricted portion corresponding to the perforation of the membrana tympani through which they have protruded.

Their consistence varies with their intimate histological structure, and to some extent also with their age.

The majority of aural polypi are benign, although malignant growths are also met with, springing either from some portion of the auditory apparatus itself, or protruding into it in the form of polypoid offshoots from some deeper-seated point of attachment.

Pathology.—Simple polypi are of two distinct types :—

1. That which is simply a localised hypertrophy of the mucous membrane, containing all its normal elements in varying proportion.

2. That which originates in granulation tissue and undergoes various histological changes.

The first variety is extremely rare in the ear, but common in the nose, since the anatomical structure of the ear is unfavourable to its growth (*vide* "Anatomy," p. 148). The tympanic lining everywhere except close to the ostium tubae is not only free from glands and lymphoid structures, but is so thin and attenuated as to be simply a modified periosteum covered with squamous and cubical epithelium.

To the second variety belong 99 per cent of simple aural polypi which originate almost invariably in granulation tissue, and are often associated with diseased bone, as in the nasal cavities. This can be readily seen on studying sections of aural polypi of all sizes and duration.

It will be found that although there may be marked variations in the actual and relative proportion of the individual structures, there is nearly always a preponderance of the lymphoid or small cell element (granulation tissue).

Each polypus consists of—

1. Surface epithelium.
2. Fibres or stroma.
3. Cells, wandering or fixed.
4. Matrix.
5. Blood or lymph vessels.

The surface epithelium is nearly always of the stratified squamous type, even when growing in and from the antro-tympanic cavity. In very rare instances it may be cubical or short columnar, covering the pedicle where it is intra-tympanic, but never ciliated.

Beneath the epithelium is often found a bright homogeneous hyaline basement membrane, forming a species of capsule enclosing (in relatively young or recent formations) lymphoid cells embedded in a matrix yielding mucin and globulin, and penetrated by vascular capillaries whose walls simply consist of elongated epithelioid cells. In polypi of older growth, white or gelatine fibres appear either as dense strands or as a stroma of delicate interlacing filaments whose spaces are distended with mucin and globulin, and contain wandering leucocytes and plasma cells.

Well-formed arteries and veins are prominent structures and become proportionately of considerable diameter and thickness in the pedicle. Among the bundles of white fibres fusiform and branched connective-tissue cells or fibroblasts will be found, while islands or masses of lymphocytes occur in considerable numbers, especially as the sections approach the pedicle or point of attachment. This lymphocytic infiltration is a much more prominent feature of aural than of nasal polypi, and should be considered the original structure, seroedematous, myxoedematous, fibrous, and other changes being subsequent and dependent upon nutritive and local influences (Fig. 119). Scattered about the polypus, small hyaline spheres will often be seen, similar to those occurring in carcinomatous and other growths (Russell's bodies, etc.). They are probably degenerated nuclear relics (plasmo-somes).

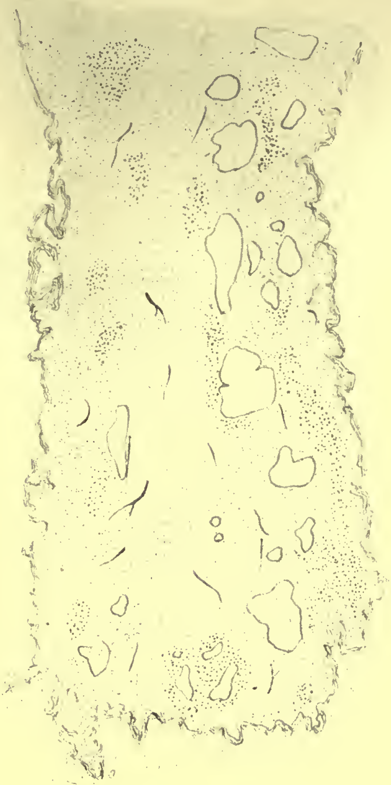


FIG. 119.—Cystic aural polypus. Mag. $\frac{3}{1}$.

What have been described as gland ducts are really hollow cylinders of invaginated epithelium (cubical and columnar) derived from the site of origin of the polypus. They may become the seat of cysts.

In some polypi, large tracts of vascular spaces are the most prominent features.

It will thus be seen that polypi will vary according to the predominance of certain constant structural elements, and may therefore be fibrous, mucous, vascular, or cystic, all arising in the first instance from granulation tissue.

Their exact nature cannot be accurately determined by macroscopical features alone, although a uniform translucency may presumably indicate an ordinary myxoedematous or seroedematous growth (Fig. 120). Should the polypus, however, show marked opacity or have a sarcous appearance, it should be regarded with suspicion, especially if any point of its surface be rough. In every instance it should be examined microscopically, especially its attached end. The writer has reported two cases which consisted everywhere of a simple myxoedematous structure except near the pedicle, where, in one instance an endothelioma, and in the other an epithelioma, was recognised. It is therefore expedient to examine not merely a small fragment but sections from each part of the growth.

As already mentioned, osseous disease very commonly occurs with polypi which spring from the adjacent granulation tissue.

Bacteria of all kinds are always found on the surface of polypi, and very often in their substance. They may be demonstrated by the Gram–Weigert method in the lymph spaces, but their presence is probably only coincidental, except in the case of tubercle bacilli and streptothrix, which are responsible for granulomatous formations which subsequently become myxoedematous or fibrous.

The matrix contains mucinogen, which is very hygroscopic, and absorbing water becomes mucin. Seroedematous changes may be due to constriction of the pedicle, limiting the venous and lymph return-flow, hence many polypi increase rapidly in size, by addition to the matrix, rather than by increase in the number of cell elements (Fig. 121).

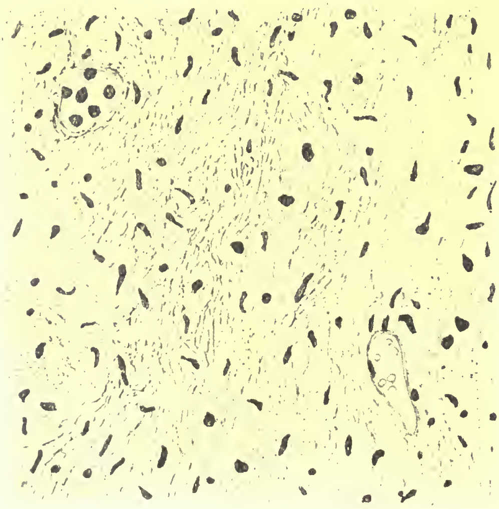


FIG. 120.—Myxoedematous fibroma. Portion of a simple polypus. Obj. $\frac{1}{6}$ in.

Symptoms.—The symptoms produced by the presence of a polypus in the ear vary according to its size and vascularity. In many cases, no symptoms of any kind are complained of, the growth being discovered in the course of an ordinary examination of the ear. At other times a feeling of fulness and weight in the head is experienced, together with intermittent tinnitus and vertigo. The amount of discharge and the amount of obstructive deafness vary greatly, and depend to a large extent upon the size and situation of the growth, the cause of the original otitis media, the presence or absence of bone disease, and the particular segment of the middle ear principally involved. Pain is seldom complained of in cases of benign growths except when some intercurrent inflammatory affection is present, or where there is mechanical retention of secretion.

Intermittent haemorrhage from the meatus is often one of the first and most constant symptoms of the presence of polypi. It is rarely profuse except in cases of malignant disease. Most frequently the discharge is merely blood stained.

In exceptional cases intractable and paroxysmal ear-cough, spasmodic muscular contractions, and even epileptiform fits have been caused by the presence of aural polypi, and have been cured by their removal.

Terminations.—Polypi with thin and delicate pedicles occasionally slough or come away when the ear is syringed, the current either twisting the pedicle or the nozzle of the syringe causing its rupture. Spontaneous atrophy and disappearance of a polypus is very unusual, the author having only seen one well-marked case of the kind, in a growth which entirely filled the meatus and gradually became atrophied, all treatment having been previously refused by the patient.

Adhesion of the growth to the walls of the meatus and its complete stenosis are exceptional results.

Diagnosis.—The diagnosis of an aural polypus seldom presents difficulty although it may be confused with a swollen and inflamed membrana tympani, with an oedematous tympanic mucosa, with an aural exostosis covered by inflamed integument, or with an haemorrhagic bulla, as occasionally met with in post-influenzal otitis media. As in the nose polypi both single and multiple may be due to or associated with foreign bodies. The history of the case, the presence of a purulent and slightly blood-stained discharge, and the evidence obtained by careful use of the probe, should at once serve to clear up any doubt. Granulation tissue protruding from the mouth of a fistula in the posterior wall of the external ear should be differentiated from a polypus on account of its being usually associated with caries of the walls of the meatus or mastoid cells.

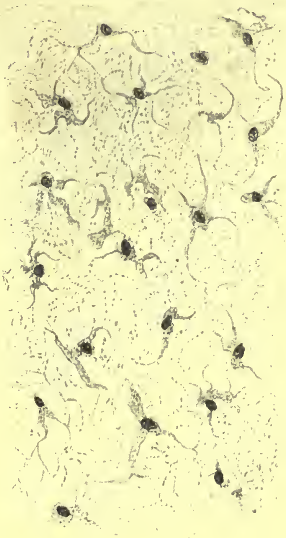


FIG. 121.—Aural polypus, showing seroedematous tissue. Obj. $\frac{1}{8}$ in.

Malignant growths arising in the immediate vicinity of the middle ear and fungating through it in the form of a polypus frequently present difficulty in differential diagnosis. Such growths are, however, as a rule very vascular, of a greyish and sloughy appearance, and tend to recur rapidly if interfered with.

Even microscopic examination of a portion of the growth does not always clear up the diagnosis, the chief difficulty lying in the fact that often only a partial examination is made, the whole fragment not being completely removed, and the superficial portion presenting merely a myxoedematous structure.

Prognosis.—Aural polypi when single and springing from the walls of the meatus are, as a rule, easily eradicated and seldom recur. Middle-ear polypi, however, from the fact that their actual points of attachment may be deep-seated and beyond the reach of local applications show considerable tendency to recurrence. Much depends upon the completeness of removal and the thoroughness with which after-treatment is carried out.

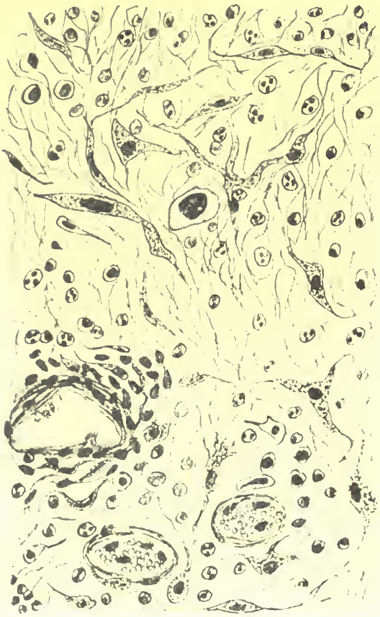


Fig. 122. Polypus from chronic suppuration of middle ear, showing seroedematous formation in a granuloma. Obj. ⅛ in.

So long as any caries or suppuration exists a tendency to recurrence will persist. Hence after removal of the growth, antiseptic, alcoholic, or caustic treatment should be steadily persevered with, and every attempt made to induce cicatrisation of the perforated membrana tympani.

With regard to any improvement of hearing following removal of a polypus, the prognosis should always be guarded, as it is not possible to accurately gauge the condition of the middle ear until after its complete eradication. In most cases the clearing out of the middle ear and the partial if not complete arrest of suppuration bring about some improvement in audition.

Treatment.—The various methods of treatment are :—

1. The local application of caustics.
2. The alcoholic bath.
3. Electro-cauterisation.
4. Interstitial injection of rectified spirits, formalin, or pure carbolic acid.
5. Removal by means of instruments, *e.g.* snares, forceps, or curettes.

1. In the case of small sessile and vascular growths, the local application of caustics is frequently efficacious. The drugs most commonly employed for the purpose are nitrate of silver, perchloride of iron,

chromic acid, tri-chloracetic acid, fuming nitric acid, acid nitrate of mercury, and anhydrous phenol.

After having syringed, disinfected, and anaesthetised the meatus, a cotton-tipped probe is dipped into the solution to be employed, and passed into the meatus under good illumination. The surface of the growth is carefully painted, a little pressure being used to rub the escharotic well into the tissues. The effect of the caustic is much intensified by a preliminary scarification of the surface of the growth. Or a suitable probe may be taken and tipped with a crystal of the medicament, the actual application being made as above described. The effect is the production of a localised slough which is allowed to detach itself, or is gently picked off by forceps, or syringed out before a second application is made. The number of applications necessary to destroy a polypus varies with its size and consistence.

Prior to the application of the caustic it is advisable to anaesthetise the parts with cocaine or with a solution of cocaine in aniline oil.

Nitrate of silver and chromic acid, from the fact that they produce a very superficial slough and that their application is attended with considerable after-pain, are seldom employed. Perchloride of iron is, on the other hand an effective and deeply penetrating caustic, and, like fuming nitric acid, is of value in the destruction of hard fibrous growths.

In the application of any strong caustic remedy, great care should always be taken to localise its action for fear of inducing cicatricial adhesion and even stenosis of the meatus. Should severe pain follow the application of chromic acid, it may be at once relieved by the insufflation of bi-carbonate of soda, or instillation of a warm solution (gr. xv. to oz. 1).

2. *The Alcoholic Bath.*—The frequent instillation of rectified spirits into the auditory meatus causes a gradual contraction and at times actual disappearance of aural polypi. This method is more especially of value in those cases where the growths are small, soft, vascular, and deeply situated. Although very strongly advocated as an efficient method of treatment, the writers have found it of value in only a limited number of cases. It is, however, useful when operative treatment of any kind is refused by the patient, and in young and nervous children. It is also useful when, from stenosis of the meatus, the deeper portions of the middle ear are not clearly visible, and instrumental treatment is consequently almost impossible. It is contra-indicated in cases of caries of the temporal bone, in inflammatory affections of the auditory meatus, and when its application causes severe deep-seated pain.

After having cleansed and dried the ear a warm solution of rectified spirits is poured into the meatus and allowed to remain in contact with the tissues for from twenty to thirty minutes, two or three times daily. Should undiluted rectified spirits cause severe burning pain it is well to commence with a dilute solution (30 to 40 per cent), and gradually increase its strength until pure spirit can be borne.

The writers have found the addition of a few drops of formalin to the lotion materially increase its efficacy; but its application is not painless. Ordinary methylated spirit should on no account be used.

One method is as follows: instil pure aniline oil (which abstracts water) for fifteen minutes, then absolute alcohol and water, equal parts, and, finally, absolute alcohol with or without formalin.

This plan of treatment should be continued for from two to three months before definitely deciding that it is incapable of destroying the growth.

3. *Electro-cauterisation.*—This method is of undoubted value in the case of readily accessible and sessile growths when the meatus is large and roomy. It is rapid and thorough in action and produces hardly any after-pain or reaction. It should, however, only be employed by those thoroughly conversant with aural technique.

Very fine cautery points are required except in those cases where the growth is hard, fibrous, and sessile, when flat points are useful. Before the actual application of the cautery point the polypus and its immediate neighbourhood should be anaesthetised. The cautery point is introduced into the meatus and pressed gently but firmly against the growth, when the circuit is at once closed. The immediate effect is the production of a white eschar, and complete obliteration of the blood-vessels, accompanied by a hissing noise and the production of smoke, which should be at once blown from the ear. Two or three successive applications may be made at one sitting. Cicatricial contraction in the deeper parts of the growth and in the adjoining oedematous mucosa is at once set up, with the result that even large polypi may be rapidly and almost painlessly destroyed. In the intervals between the various applications of the cautery point the instillation of a saturated alcoholic solution of boracic acid or formalin will be found of service. The cautery should not be used in the case of deep-seated and partially inaccessible growths, nor in those springing from the immediate neighbourhood of the labyrinthine windows.

To prevent injury to the meatal walls a long and delicately constructed silver speculum should be inserted reaching as near to the surface of the growth as is possible.

4. *Destruction of polypi* by the interstitial injection of rectified spirit or alcoholic solutions of formalin or carbolic acid is at times useful. To prevent pain a few drops of a 10 per cent solution of cocaine should first of all be injected into the growth, or Neumann's method of inducing local anaesthesia (p. 56) employed. An ordinary hypodermic syringe with a specially constructed and long needle is used for making the injection, from twenty to thirty drops of the solution being forced into the growth under pressure. The result is the induction of cicatricial contraction followed by atrophy, and at times by complete disappearance of the growth.

5. In the majority of cases instrumental removal by means of snare, forceps, curette, or sharp spoon is at once the most speedy and the most efficacious method of treatment. The particular instrument to be

employed depends upon the size and situation of the growth, and whether it is pedunculated or sessile. Pedunculated growths are best removed by means of the cold wire snare or Wingrave's cross-action loop forceps (Fig. 123). With this forceps the growth may be seized, twisted, and avulsed. The loop of the snare (Fig. 124) is drawn out and enlarged in an elliptical manner so as to readily encircle the growth. It is then passed into the meatus along its floor, and gently insinuated until it meets with definite resistance. By then raising the handle of the snare and drawing the pool of wire home the growth is severed and drawn from the meatus, or, if need be, picked out with a pair of forceps. Haemorrhage is, as a rule, sharp, but is easily controlled by packing the meatus with strips of gauze, or syringing with either hot or very cold sterilised water. After it has been arrested the remaining portion of the growth should be destroyed by the application of anhydrous phenol, chromic, or trichloracetic acid, alcoholic solutions of boracic acid or of formalin being used to expedite contraction.

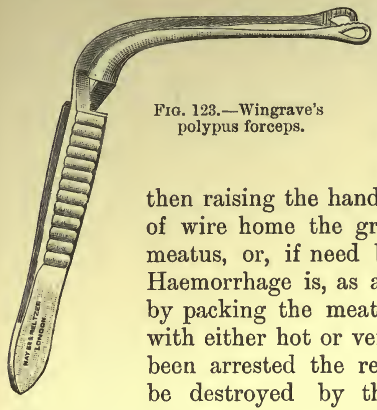


Fig. 123.—Wingrave's polypus forceps.

Severe haemorrhage from the ear following the removal of polypi is unusual, except in those cases where the pedicle of the growth is angiomatous in structure, or where it happens to be malignant. Under such circumstances it may be necessary to apply strong perchloride of iron lotion to the bleeding stump, to instil adrenalin solution (1 to 1000), to insufflate tannic acid powder, or to pack the meatus lightly with antiseptic gauze.

Smaller growths, especially if non-pedunculated, are best removed by means of sharp spoons, curettes or forceps (Hartmann's).

After a preliminary cocainisation a sharp spoon or curette is introduced, under good illumination, over the growth. With a rapid and firm downward and outward movement the growth, generally adhering to the instrument, is scraped out, exposing a raw and bleeding base.

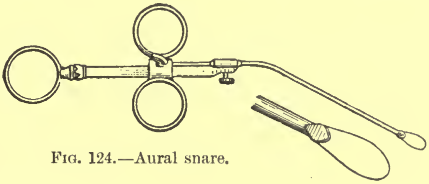


Fig. 124.—Aural snare.

Small granulation polypi springing from the lining of Prussak's space, from the epitympanum, or from the depths of the middle ear may readily be removed with Hartmann's forceps.

The complete evulsion of a polypus is seldom possible except in the rare event of its growing from the walls of the auditory meatus, unless the pedicle be well twisted. As a rule a portion of the growth is left behind and requires careful local treatment until entirely destroyed, otherwise recurrence is almost certain.

Granulomata.—The occurrence of granulation tissue in the meatus and middle ear is so frequent that a consideration of its differential histology and the diagnostic significance of its structure is frequently called for.

In the ear the following types are found:

1. Non-specific or simple.
2. Tubercular.
3. Lupus.
4. Syphilitic.

It must not, however, be forgotten that granulation tissue is often a prominent associate of malignant disease, and if only a small fragment be removed for microscopical examination and diagnosis the serious and real nature of the process may easily be overlooked.

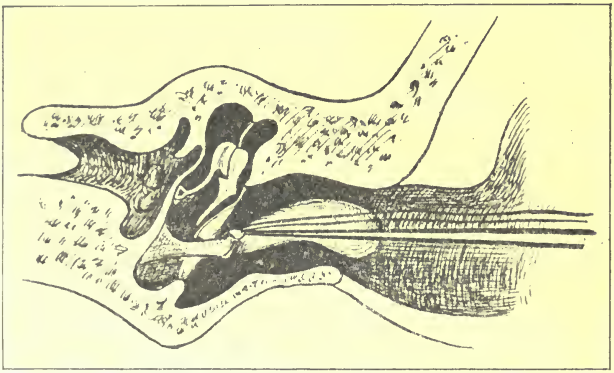


FIG. 125.—Removal of polypus, showing the loop of the aural snare encircling the growth close to the membrana tympani (semi-diagrammatic).

Further, the persistence of granulation tissue is strongly suggestive of an osseous lesion which careful probing will usually verify.

1. The first or *non-specific type* of granuloma is the commonest and may be associated with any form of bacterial infection, pyogenic or non-pyogenic (Fig. 126). It may occur in two distinct types: (*a*) the bare or uncovered, which is rough, red, and bleeds easily on touching, and (*b*) the covered or capsulated, in which one or more layers of epithelium form a distinct sheath, giving it a smooth appearance. This when large and pedunculated is generally called a polypus. It, however, differs from an ordinary nasal polypus in being entirely free from the glandular and other elements belonging to a mucous membrane.

Granulation tissue histologically consists of lymphocytes held together by a homogeneous matrix of globulin, collagen, or mucigen, which after fixation and hardening appears often as a delicate meshwork pierced by thin loops of capillaries, each surrounded by a lymph space. These vessels are formed by elongated mesothelial cells (angioblasts) which are often seen to multiply. This tissue may either undergo sclerotic changes or become myxoedematous, *i.e.* the matrix holding mucigen swells and becomes mucin by hydrolysis, and assumes a polypoid character. Its lymph spaces may also be distended—a state of seroedema.

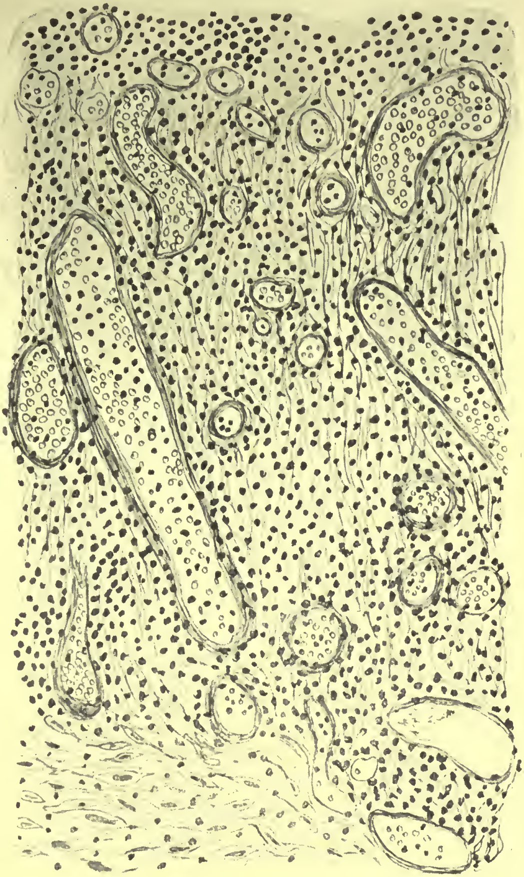


Fig. 126.—Granuloma simplex, non-specific. Obj. $\frac{1}{16}$ in.

Whenever the underlying bone is involved granulation tissue is especially exuberant, and may often assume the polypoid type, with a striking and rapid increase in size. Such a condition is frequently associated with a small carious focus, while a diffuse crop of granulations may indicate a large area of caries. This remarkable increase in size is probably due to several factors. In the polypoid type the granulation tissue, instead of being bare, is covered with one or more layers of stratified epithelium which interfere with the escape of "wander" cells and increases the cellular bulk of the mass. Blood-vessels are also more thoroughly developed, and a mucous or serous oedema increases the bulk of the matrix. Plasma cells are numerous.

In all forms of granuloma it is very difficult to attribute the inflammatory process to any one particular organism since the infection is nearly always poly-microbic. Too much importance must not be placed upon those organisms found free in the discharge; but search should be made in the tissue itself, which is not difficult when variations in the Gram method of staining are employed. Bacteria found in the lymph spaces or in the leucocytes should be considered of greater causal importance than those found in the discharge or on its surface. The commonest pyogenic bacteria found are *staphylococcus*, *streptococcus*, and also the *bacillus pyogenes foetidus* and *bacillus pyocyaneus*.

Occasionally cyst-like cavities appear in granulation polypi which originate either in epithelial inclusions or by distension of lymph spaces. They are, however, far less common in the ear than in the nose.

Multinucleated or syncitial cells are often seen in the granulation tissue of the ear. They are not so large as the giant cells of tubercle, their nuclei being disposed irregularly and closely resembling myelocytes. They may occur singly or in groups of five to ten, and are probably derived from the endothelium as a result of irritation by fatty acids (White) (Fig. 127).

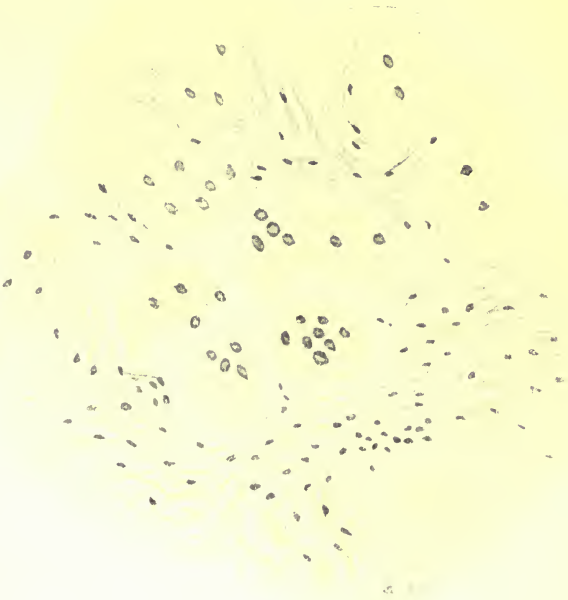


FIG. 127.—Syncitial cells from Granuloma of mastoid antrum. Obj. $\frac{1}{8}$ in.

Exaggeration of the blood- and lymph-vessels may be so pronounced as to give the appearance of an angioma on section, the lymphocytic elements being few. In such a condition the discharge is scanty, while on the other hand when the granulations are bare it is profuse and contains a large excess of lymphocytes, a significant and reliable diagnostic feature.

2. The next form—*Tuberculoma*—has certain definite features which are characteristic, and should afford sufficient evidence for diagnosis.

In addition to lymphocytes there is well-marked activity of the mesothelial elements which are the essential features of a tuberculoma. They seem to entirely replace the lymphocytes and form solid masses of "tubercles," surrounded by a zone of lymphocytes. At or near the centre, giant cells are seen which may be formed either by fusion of mesothelial cells or by direct nuclear division without cleavage of the cytoplasm (Fig. 128). This tissue is practically non-vascular, no capillaries being seen in it. As the large mesothelial cells become more compressed, caseation soon follows, the cytoplasm becomes granular, the nuclear stroma is broken up, and the para-nucleus escapes as a deeply staining sphere, the last part of the cell to degenerate. This change may be due to the action of intracellular trypsin. This mesothelial activity may be caused by tuberculo-toxin since the bacilli of tubercle are often absent. If present, however, and having resisted the action of alcohol, they confirm the diagnosis and show that the process is relatively acute, for in chronic conditions bacilli are rarely found. Further, obliterating arteritis is sometimes seen, but less often so than in syphilis.

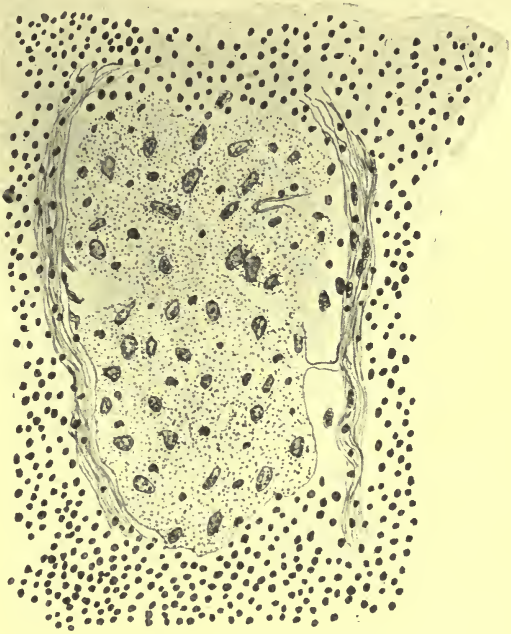


FIG. 128.—Tuberculoma from the meatus. Obj. $\frac{1}{8}$ in.

3. *Lupus* granuloma is very similar to that of tubercle, but has the following differences:

(*a*) Less tendency to caseate and a greater tendency to sclerosis.

(*b*) Giant cells irregular in shape.

(*c*) Absence of tubercle bacilli.

(*d*) Diffuse and irregular distribution of mesothelial cells, considerably in excess of the syphilitic, but less concentrated than in the tubercular.

(*e*) The presence of hyaline spheres (Gram +).

4. *Syphilitic* granulomata may occur at any period of the disease, but as granulomata proper they belong strictly to the tertiary stage.

Although the gross characters of a *primary* sore are so different from those of a granulating area that a differential diagnosis presents but little difficulty, a comparison of its histological features with those of other syphilitic eruptions and other granulomata may here be briefly considered.

The characteristic changes are :

1. Marked perivascular lymphocytosis.
2. Presence of leucocytes or "wander" cells in the loose connective tissue mixed with lymphocytes.
3. Slight activity of the mesothelium, endo- and peri-vascular.
4. Invasion of the Malpighian and upper layer of the epidermis by lymphocytes and leucocytes, together with disappearance of the upper or horny layers, and slight vacuolation of some of the surface cells.
5. Presence of *spirochaeta pallida.*

The writers have never seen any giant cells as described by several authors in this stage, its essential features being infiltration of the subcutaneous tissue and perivascular lymphocytosis without necrosis, and but slight mesothelial activity.

The "*secondary*" form, "mucous patch" or "condyloma," is not rare in the meatus, and chiefly differs in degree from the primary. The surface epithelium shows greater disturbance, most of the cells being swollen and vacuolated, the nuclei showing all stages of fragmentation with pyknosis, sometimes heteromitosis. Large and reticular spaces are found containing lymphocytes and leucocytes, while there is considerable distension of the papillae with enlargement of the inter-papillary digitations. In the deeper parts there is oedema with distended lymph spaces, containing wandering leucocytes and lymphocytes. Mesothelial activity is not much more in evidence than in the primary sore. The essential feature is hypertrophy of the papillae and inter-papillary epithelium with hyperaemia of the vessels and gelatinous degeneration of the connective tissue fibres. In this stage also the characteristic spirochete may be found.

Spirochaeta Pallida (*Treponema pallidum*).—At this point it will not be inappropriate to give a few details respecting the now well-known micro-organism discovered by Schandin. Although it has so far failed to justify its claim to specificity by conforming to the postulates of Koch, its almost invariable occurrence in connection with the first two phases of syphilis and its constant morphological characters are sufficient to afford it a diagnostic significance which we cannot afford to disregard. Histologically, it is seen in greatest numbers in sections of the lung and liver of still-born children, the subjects of congenital syphilis, but a short experience of the technical details of film-separation will afford success in its diagnostic demonstration. Even in films, as a rule, unlike most other micro-organisms, it is not seen in the cells, probably in great measure owing to staining difficulties. Its habitat is in the lymph or plasma, therefore it can readily be obtained by "needling" either the sore itself or the adjacent glands. Scrapings from the surface of an ulcer are often unsuccessful, due either to the fact that the spirochaetae do not escape superficially, or that in the case of the mouth they are rapidly removed by attrition and the secretions.

Morphologically it resembles a short closely-coiled wire spring when seen in silver-stained sections of tissue, while in films it appears to be larger owing to its coils being farther apart as a spring would be if stretched. Consequently its length, from 5 to 15 m. or more, with from 10 to 15 turns, varies considerably as compared with other spirochaetae, such as those already referred to in aural discharges (*spirochaeta refringens* vel *foetida*). It is as a corkscrew is to an eel or a whiplash. Some observers describe flagella, others a mantle at its ends. These, however, are difficult to demonstrate. The ends may be blunt or sharp, according to whether complete or broken.

To demonstrate it in the tissues Levaditi's silver method is the best, but for films such as are employed in ordinary diagnostic work it is best stained by (1) Giemsa's solution, or (2) gentian-anilin violet or methyl violet and iodine.

Material for film work may be obtained in two ways, superficial and deep.

The surface method, not quite so reliable as the other, is as follows: —Lightly cleanse the surface of the ulcer or condyloma with cotton wool moistened in 2 per cent saline solution, gently scrape the surface with a blunt scalpel, compress the base of the ulcer and collect the exuding lymph on a slide. Spread and fix in warm air. By far the better method, however, is to introduce an ordinary hypodermic needle into the substance of the ulcer or into the adjacent hard glands. A few drops of lymph are withdrawn which, when spread and fixed on a slide, may be stained as follows:—Mix ten drops of Giemsa's solution with two drops of 1 in 1000 solution of carbonate of potash, and 50 drops of distilled water in a wide test tube. Place the slide in this solution and keep it in an incubator or warm place for twenty-four hours. Wash with tap water, dry in warm air or incubator, and examine with a 1-12th oil immersion lens. Balsam and cover glass may be used at will. Although time may be saved by heating, the writers have obtained the best results by the longer exposure.

The spirochaeta may also be seen in a wet film without staining, by the new dark ground method of examination.

Careful comparison with micro-photographs and familiarity with the common putrefactive spiral forms will prove efficient aids to a differential diagnosis.

Granuloma of the *tertiary* stage has some definite peculiarities, viz.:

(*a*) Well-marked vascularity.

(*b*) Endo- and peri-arteritis obliterans.

(*c*) Marked tendency to sclerosis, a colloid swelling rather than caseation.

(*d*) Marked mesothelial activity, even to the formation of irregular "giant cells." This, however, differs from tubercle in not being sharply defined or rounded, but diffuse.

In all forms of granulomata plasma cells are well marked, especially in the more chronic processes. In simple granulations eosinophile granular cells are specially numerous, as also in the discharge. The surface epithelium is invaded by lymphocytes, and is gradually replaced by them, eventually forming a rough, tuberculated, moist or purulent area.

Although the foregoing may be taken as distinguishing features, and may help as guides to differential diagnosis, it sometimes happens that the small fragment available for examination fails to tell us more than that it is part of an inflammatory process, and that the tissue is a granuloma. This may be very disappointing when positive evidence is demanded; still there are but few instances in which a fairly presumptive diagnosis of specificity may not be made, either from a careful study of the cytological details or by a diligent search for bacteria.

Considerable difficulty may be experienced in differentiating a granuloma from the early stages of a small round cell sarcoma, when only a minute fragment is available. Uniformity in the size, shape, and grouping of the cells with heteromitotic changes in the nuclei may, however, sufficiently indicate a neoplastic nature, or at least suggest the necessity for further observation.

The histological characteristics of Noma are not diagnostic, but a small Gram – bacillus with an equatorial clear space is said to be its specific micro-organism.

CHAPTER XXI

CHOLESTEATOMA

Cholesteatoma.—A cholesteatoma occurs in aural disease in three distinct types:

1. As an encapsuled mass without any suppuration.
2. As an epidermal accumulation associated and mixed with chronic suppurative changes.
3. As a developmental or primary deposit in the petro-mastoid bone, probably independent of any aural lesion.

The first form is that which has a practical connection with our subject.

A cholesteatoma may appear either as a sharply circumscribed and encapsuled pearly mass in the meatus, the tympanic cavity, or the antrum, or as a soft putty-like irregular mass mixed with blood or pus similar to caseous material, for which it may readily be mistaken by the naked eye. Further, it may be septic or sterile, a distinction of much clinical significance. Histologically, it consists of densely packed laminae of dead squamous epithelial cells, which have the remarkable property of staining like tubercle bacilli by the Ziehl-Nielsen method, *i.e.* having acid-fast, and to a certain extent also alcohol-fast properties, and affording a prominent feature in films of aural discharge in cases of chronic suppuration (*vide* "Discharges," p. 246). Some of the cells show a bright area representing the nucleus, but not selecting the blue stain at all; others (the majority) afford no evidence whatever of a nucleus. Among these squames may often be seen the flattened rhombic crystals of cholesterin and some amorphous fatty granules. The containing capsule, when present, consists of laminae of white connective tissue fibres, sometimes with a few fusiform nuclei of old fibroblasts, but generally devoid of nuclear elements. The lining is composed of five or more layers of epithelial cells resembling the Malpighian layers of the epidermis. The transition from columnar to squamous is well marked (Fig. 129). It is chiefly in cholesteatomata taken from the antro-tympanic cavity that any signs of an epithelial lining such as occurs in dermoid cysts can be seen. This lining consists of a few layers of nucleated squames derived from the modified lining of the cavity. The smooth, pearly, glistening capsule so often seen in antral cholesteatomata has been found by the writers to be sometimes quite devoid of any living epithelial lining, *i.e.* cells possessing demonstrable nuclei, and therefore capable of multiplication.

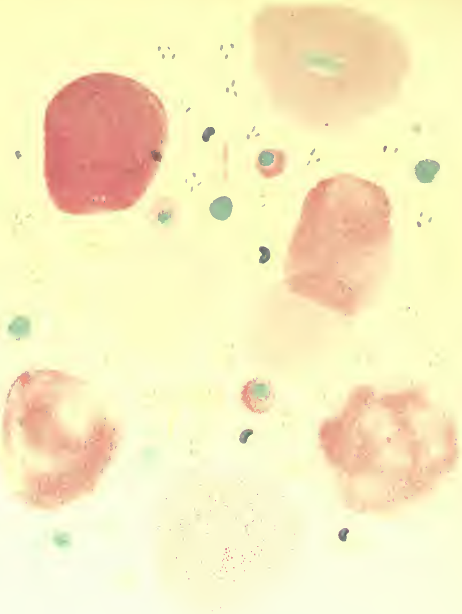
Pathology.—The origin of cholesteatomata is primarily dependent upon the existence of an epithelial surface which produces cells of a flattened or squamous type. Such does not exist in the antro-tympanic cavity in its normal state, but like other regions when subject to irritation by bacteria, exposure to the air, or other abnormal states, the original cubical, columnar, or ciliated epithelium becomes transformed into stratified squames similar to the Malpighian layer of the epidermis. It has been suggested that the cuticular epithelium of the meatus grows inwards, *i.e.* actively invades the tympanic chamber, and replaces the normal lining which has been destroyed or damaged by inflammation. Such may or may not be the case. It is not supported by comparison with similar transformations of epithelium in other parts of the body, *e.g.* an inverted uterus is rapidly covered with epithelium similar to that of the cervix and vagina; a nasal polypus, even when situated deeply in the nasal fossa, may be covered with squames instead of columnar cells. Localised areas of the turbinals often lose their ciliated epithelium, which is replaced with squamous when diseased as in atrophic and even hypertrophic forms of rhinitis. The columnar or palisade epithelium of a prolapsed rectum also becomes epidermal in character. Further, we have a physiological transformation of the early columnar epithelium of the oesophagus into stratified cells. Such examples amply illustrate a direct change of histological features which follows from alterations in the physical conditions to which the surface epithelium is exposed a true metaplasia.

FIG. 129.—Capsule of cholesteatoma. Obj. $\frac{1}{8}$ in.

In the case of the ear an entirely new and foreign type of epithelial lining

PLATE VI

1



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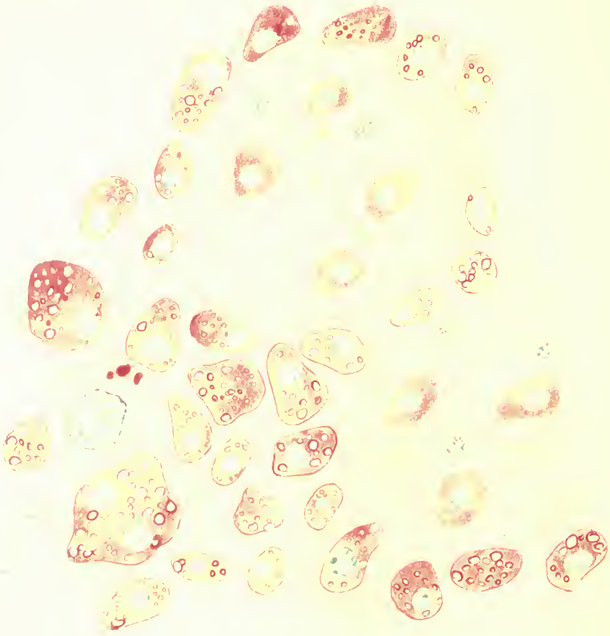

Fig. 1.—Discharge in chronic suppuration of the middle ear with cholesteatoma, acid-fast squames, leucocytes, lymphocytes, and spirochaetes. Obj. $\frac{1}{12}$ in.

Fig. 2.—Plasma cells in a granuloma from the middle ear. Obj. $\frac{1}{12}$ in.

To face page **281.**

results from an inflammatory or irritant process, a type in which the cells are more rapidly produced and not so easily got rid of as when normal, therefore they accumulate just as in the skin and tonsil lacunae. In fact the tympanic lining assumes a cutaneous type and desquamates in a similar way and under some conditions even more rapidly than in skin, especially in children after the radical operation.

These laminated, closely-packed masses of dead epithelial cells are evidently produced by metaplasia. They undergo keratinoid changes similar to epidermal cells, they are not easily absorbed, and therefore accumulate and exercise a constant pressure on the surrounding structures, either producing erosion by passive pressure or forming a complete cast of the cavity which they fill.

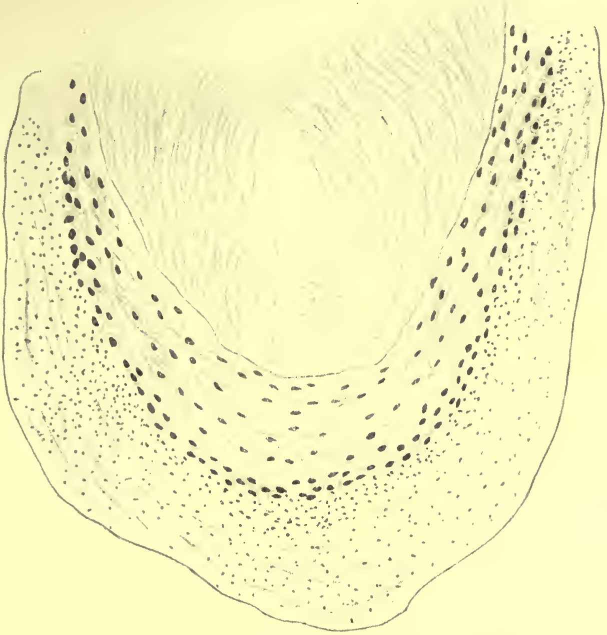

Fig. 130.—Capsule and lining of cholesteatoma. Obj. ⅔ in.

In many sections of antral contents the capsule is seen to be the seat of living cells—leucocytes, lymphocytes, plasma cells, and mesothelium, which may be responsible for active erosion of the surrounding bone (Fig. 130).

The absence of an active or living lining to the antral capsule does not necessarily prove that there never was one in this situation.

A similar cholesteatomatous formation is very common in the tonsils whose lacunae are often distended by "pearls" of laminated squamous epithelium, the oldest ones free from nuclei and possessing acid-fast properties. They may also be seen in nasal polypi of long standing, and are certainly not peculiar to the ear.

The exact *pathogenesis* of cholesteatoma has been the subject of much discussion. That it may occur as a primary formation—a foetal inclusion—is undoubted. Such inclusions have been met with in the *recessus epitympanicus*, the posterior end of the middle-ear cleft, and even in the posterior cranial fossa. In a case recorded by Körner,[1] a mass equal in size to two hen eggs and extending from the posterior surface of the pars petrosa to the torcular Herophili was successfully removed by operation, it having become infected by an intercurrent attack of post-influenzal mastoiditis. Cases have also been recorded by Lucae and Kuhn in which the primary origin of cholesteatoma was beyond question.

Virchow regarded a cholesteatoma as a heteroplastic tumour, Von Tröltsch as a retention tumour, Wendt as due to a desquamative inflammation of the tympanic mucosa, whilst Habermann and Bezold consider that its formation is due to migration of epithelium from the auditory meatus through an already perforated membrana tympani. The various factors which clinical experience would indicate as being responsible for its production are the presence of chronic suppurative otitis media, more especially when a marginal perforation exists; excessive desquamation of the cutis of the auditory meatus, and some obstructive lesion in the meatus or of the tympanic or tubal mucosa interfering with the free exit of purulent secretion from the middle ear, or its normal ventilation. Such obstructive lesions may be due to hyperostosis of the meatal walls, the presence of polypi, cicatricial adhesions, or sacculated spaces in the tympanic mucosa. In addition an obstructed Eustachian tube, by interfering with the normal ventilation of the middle ear and, hence, with the functional activity of its mucous membrane, predisposes to the incursion of the cuticular lining of the auditory meatus.

Since perforation, or absence of the tympanic membrane, practically always coexists with cholesteatomata, it follows that the vapour tension of the antro-tympanic cavity must fall to that of the surrounding atmosphere, with the inevitable result that a process of desiccation follows, and the single layer of cubical or flattened cells assumes the characters as seen in Fig. 129. Such metaplastic changes are doubtless emphasized by the irritation of dust and bacteria, just as in the case of an extroverted uterus or rectum.

Macroscopic Features.—Cholesteatomatous masses vary in size from the head of a pin to that of a walnut. When situated in the accessory spaces of the middle ear they may attain great size, and by gradual pressure cause absorption of the surrounding bony parietes, ultimately invading the labyrinth, the middle or posterior fossae, or penetrate the mastoid cortex and appear under cover of a subperiosteal mastoid abscess. The masses consist of concentrically arranged layers of stratified epithelium, for the most part non-nucleated, fat granules, cholesterin crystals, micro-organisms, and purulent debris, with or without a glistening pellicle.

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[1] *Archiv of Otolog.* 1901, xxx. 323.

In many instances the presence of a cholesteatoma is associated with caries of the tympanic or antral walls, whilst in others excavation of bone may in one part be due to pressure and in another to an already existing caries or cario-necrosis. Very extensive excavation of the temporal bone, followed at times by spontaneous extrusion of the mass, is at times met with. As the result of gradual absorption of the posterior meatal wall the antrum, tympanum, and auditory meatus may be thrown into one large cavity, or the outer labyrinthine wall may become so eroded as to be followed by complete destruction of both static and acoustic segments of the internal ear. The erosion and absorption of bone may proceed to such an extent as to leave a mere shell of compact tissue. In many instances the roof of the tympanum or antrum will be found destroyed, the dura exposed or even perforated, and in exceptional cases the cortex of the brain exposed.

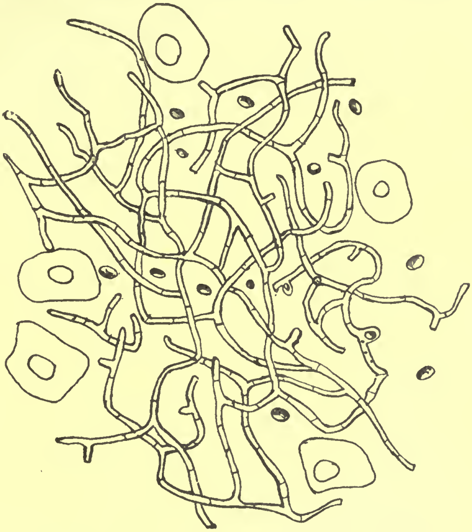

Fig. 131.—Mycelia and spores from a cholesteatoma of antrum. Obj. ⅛ in.

As a rule, the cavity in the bone produced by the gradual growth of the cholesteatoma will be found to possess smooth walls lined by a smooth and glistening layer of epithelium. This layer is in reality the inner epithelial lining of the cholesteatomatous sac and may even invade the cancellous spaces of the adjacent bone. Aural cholesteatomata may therefore appear either as part of an active inflammatory process involving the antrotympanic chamber, or they may constitute simply a passive residue of some past and quiescent process. The latter form, however, in the event of an acute infection affords exceptional facilities for serious suppurative complications.

As primary deposits in the substance of the temporal bone and on its surface they must be regarded as epithelial inclusions or "rests" of developmental origin.

Whether they always arise in epiblast (neural or epidermal) is an interesting question, since histological evidence shows that such tumours may be formed from mesoblastic elements, viz. endothelial cells. This type is by no means uncommon in connection with growths of the dura mater, in the tonsils, and in the vestigial corpuscles (Hassell's) of the thymus.

Symptoms.—Cholesteatomatous masses, if aseptic, may lie dormant within the middle ear or its accessory cavities for long periods without producing any symptoms of moment. On the other hand, suppuration around them is readily induced, and often with disastrous results should infection occur.

Their presence must, therefore, be regarded as a source of perpetual danger. Their spontaneous extrusion occasionally takes place, more especially when the mass has formed within the epitympanum, and when there happens to be at the same time extensive destruction of Shrapnell's membrane and outer attic wall.

In most cases their presence gives rise to a feeling of fulness and heaviness in the head, attended at times by attacks of vertigo. The entrance of water into the ear while washing or bathing may suddenly set up severe irritation and pain, due to the rapid swelling of the hygroscopic mass. Naturally the symptoms produced will depend largely upon the course taken by the gradual enlargement of the mass, the particular structures laid bare as the result of pressure-erosion, and the existence or otherwise of intercurrent attacks of middle-ear suppuration.

No part of the temporal bone is safe against the ravages of cholesteatoma, and fatal results follow its presence, either from general sepsis, acute osteomyelitis, or from such intra-cranial complications as meningitis, brain abscess, infective thrombosis, or encephalitis, induced as the result of a preceding or accompanying caries of the surrounding bone, or from perforation of the mass into the interior of the skull or labyrinth.

Diagnosis.—The definite diagnosis of the existence of a cholesteatoma is a matter of very considerable difficulty and is, at times, impossible prior to operation. Its presence may be presumed by the existence of acid-fast squames in the discharge, or may be rendered certain by the discovery of a portion of the mass protruding through a perforated membrane or fistula in the posterior meatal wall or mastoid cortex.

The presence of a mass of soft doughy epithelium protruding through a perforation in Shrapnell's membrane or the postero-superior segment of the membrana tympani should arouse suspicion, the more especially if it is quickly reformed after removal, and if associated with excessive proliferation of the cutaneous lining of the meatus. The repeated presence also of epidermic scales of a white or yellowish-white colour in the washings from the middle ear or mastoid antrum, especially when an intra-tympanic syringe is employed, are of diagnostic import. Such epithelial squames are acid-fast, staining readily with fuchsin, and are partially decolorised with alcohol. If of recent origin the nuclei are well marked, but if old the nuclei are invisible or but faintly indicated. Microscopical examination is indispensable ; it should be undertaken for evidence of infection of the squames, a complication of the highest significance. The existence of a deeply-seated cholesteatoma within the mastoid area can only be proved during the performance of a post-aural operation, although its presence may have been suspected on account of protracted suppuration from the tympanum, attended by imperfect drainage, evidences of marked epithelial proliferation of the walls of the cutaneous meatus, and the presence of acid-fast squames in the washings from the deeper portions of the middle-ear cleft. When septic, cholesteatomata are attended by pronounced foetor of the discharge similar to decayed cheese or smegma.

Prognosis.—The presence of a cholesteatoma is always attended by danger, the danger varying, however, according to the size, situation, and age of the mass, together with the coincidental infection. Its existence renders the cure of chronic suppuration from the middle ear an impossibility, until it has been completely eradicated, whilst its tendency to enlarge and to penetrate adjoining structures adds an additional element of danger. The more deeply it is situated and the more frequently suppuration takes place around it, the greater the danger.

Spontaneous extrusion is seldom followed by actual cure, the proliferating epithelium showing a marked tendency to invade surrounding bone and to ultimately restart the formation of the mass.

Even when all suppuration has ceased, recurrence may take place as the result of a progressive desquamative process.

Treatment.—Where the perforation of the membrane is small, it should be freely enlarged. Forcible syringing, especially with one or other form of intratympanic syringe, will, in certain cases, effect expulsion of the mass. Preliminary instillations of rectified spirit, or of salicylic acid in aniline oil or alcohol, are of value in causing its contraction and solution. On no account should watery solutions be employed, owing to the hygroscopic properties of the mass and its consequent tendency to swell. Gentle leverage with a curette (Lake), probe, or small spoon assists in certain cases in detaching the mass, and consequently renders its removal with the syringe more easily accomplished. In some cases where the meatus is stenosed from swelling of its walls, hyperostosis, or exostosis, the passage of a soft elastic tympanic catheter attached to a syringe greatly facilitates the removal of the mass. Various intratympanic syringes are also used for the purpose, *e.g.* Blake's, Politzer's, Hartmann's, or Milligan's.

With the author's syringe a continuous flow of fluid under pressure is possible, whilst during manipulation its effects may be directly watched. The syringe—of as large calibre as possible—is introduced through the perforation and made to impinge against the cholesteatomatous mass. The pressure of the fluid is regulated by the height of the reservoir, as much pressure being employed as is possible without making the patient sick or giddy. Syringing is kept up until the returning fluid comes away perfectly clear. After having cleansed the cavity it is advisable to inject warm rectified spirit or hydrogen peroxide.

Syringing the middle ear *per tubam* assists at times in the expulsion of intratympanic cholesteatomata. For this purpose warm solutions of bicarbonate of soda, peroxide of hydrogen, or normal salt solution are driven forcibly through the Eustachian catheter into the tympanum.

Portions of the mass may thus be expelled by the gradually increasing *vis a tergo* and other portions by spontaneous extrusion. The careful use of a curette may also succeed in detaching and removing small cholesteatomata, especially when favourably situated for removal as in Prussak's space.

Pari passu with the attempt to get rid of all cholesteatomatous debris, antiseptic treatment of the existing purulent middle-ear disease should be followed out.

In most cases, however, intratympanic treatment is perfectly useless, the offending mass lying much too deeply within the interstices of the pars mastoidea. Under such circumstances a post-aural operation is called for, the outer attic wall being removed and the mastoid antrum opened up, or the complete post-aural operation performed, according to the particular requirements of the individual case.

The tendency to recurrence is so great that many operators consider it advisable to maintain a permanent retro-auricular fistula, partly for subsequent inspection of the originally infected cavity, and partly because the free action of atmospheric air appears to lessen the risks of excessive subsequent desquamation and accumulation.

It has been suggested to leave the matrix of the cholesteatoma behind to act as the lining membrane of the cavity exposed by operation (Siebenmann, Hartmann, Dundas Grant). This method has, however, received but scant support from Otologists, the so-called matrix being regarded as a product of the diseased process. Histological observation has also shown that epithelial processes dip down into the cancelli of the underlying bone to form foci of further trouble; hence the necessity for getting rid of all traces of epithelium before grafting the cavity or allowing epidermisation to extend from the cut edges of one or other of the meatal flaps which may have been employed.

Siebenmann regards the matrix not as a pathological product but as an attempt at repair, and the destruction of surrounding bone as the result of pressure erosion from retention of inflammatory products.

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CHAPTER XXII

TUBERCULOUS DISEASE OF THE MIDDLE EAR AND ITS ACCESSORY CAVITIES

Tuberculous Disease of the Middle Ear and its Accessory Cavities.—Tuberculous disease of the mucous membrane lining the middle-ear cleft, or of the temporal bone, may be either a *primary* or a *secondary* infection.

The channels along which tubercle bacilli travel to reach the middle ear and temporal bone are (1) *aerial*: air passing up the Eustachian tube and depositing bacilli in one or other portion of the middle-ear tract; (2) *lymphatic*: along various lymph streams leading from adjacent tuberculous foci; (3) *Vascular*: by the arterial supply following entrance by respiratory or digestive canals; (4) through collections of *lymphoid tissue.*

Primary tuberculous infection of the mucosa lining the middle-ear cleft, or of the temporal bone itself, is now recognised as a definite disease, accurately observed cases having been recorded by Knapp, Küster, McEwen Smith, Goldstein, Horne, Milligan, and Habermann. Winkler and Brieger believe that the bacillus is first deposited in the mucosa covering the pars promontoria, whilst Küster considers that the antral mucosa is first infected. Bernstein, on the other hand, holds that the primary site of infection is in the mucosa lining the inner surface of the membrana tympani.

It is most frequently met with in infants and young children, and is especially prone to attack the cancellous tissue of the mastoid process when of haematogenous origin, and the mucosa of the middle-ear cleft when air-borne. After the fourth or fifth year it is much less frequently met with.

In an analysis of 100 cases of fatal middle-ear suppuration Whitehead found 12 to be due to tuberculosis of the middle ear, and of these 12 cases 9 occurred in children under two years of age, and in 8 the disease appeared to be primary. Various circumstances favour the occurrence of primary infection in early life. Thus the Eustachian tube is shorter (in the newly-born infant less than 20 mm. in length) and wider than in adults, while its tympanic orifice occupies a lower situation in reference to the level of the floor of the tympanum than in the adult. Its pharyngeal orifice is also situated somewhat nearer to the corresponding choana and oral cavity than in the adult, so bringing the tube more directly under the influence of air-borne and deglutory influences.

The acts of retching, vomiting, sucking, and crying in infants tend to force air towards the cavum tympani and hence to infect it. The fact, also, that by far the larger proportion of cases of primary temporal bone tuberculosis is met with amongst the poorer children of large cities, and amongst those brought up in ill-lighted and badly-ventilated rooms, lends colour to the theory of the frequency of aerial infection.

Constant association with the victims of pulmonary or other forms of tuberculosis probably also plays a part in the incidence of the disease.

With regard to tuberculous infection in general, certain observers, notably Nathan Raw,[1] insist upon the principal channel of infection being by way of the lymphatics of the alimentary tract, and consider that the feeding of children upon milk derived from tuberculous cows is mainly responsible for the frequency of the disease. Against this theory there is, however, the fact that the majority of infants are breast-fed. Of 12 cases observed by Paul Matthews[2] 6 had a family history of tuberculosis, and of 5 cases in infants under one year of age 3 had been entirely breast-fed prior to admission to hospital, whilst 1 had been brought up upon a patent food.

Secondary infection of the middle-ear cleft is most frequently found amongst those suffering from pulmonary phthisis, and especially during the stage of cavitation, from tuberculous disease of the larynx, pharynx, bones, joints, glands, and occasionally naso-pharyngeal adenoids. Its frequent occurrence during the later stages of pulmonary phthisis is in part due to the accumulation of bacillary-laden sputum in the naso-pharynx and around the orifices of the Eustachian tubes which the enfeebled patient is unable to get rid of. In addition, in such advanced cases the adipose tissue normally disposed around the Eustachian tubes becomes shrunken (Ostmann) and the lumen increased from lack of support by the surrounding tissue, with the result that infected sputum more readily reaches the cavum tympani.

Symptoms.—The symptoms of aural tuberculosis are both general and local. The former depend to a large extent upon the organ or organs principally involved, the degree of constitutional disturbance, and the presence or absence of marked toxaemia. Rapid loss of flesh, frequent attacks of diarrhoea, night sweats, and general prostration are common symptoms in many cases. It is remarkable, however, how in certain cases extensive local disease may be present, without any marked constitutional effects. Dryness of the skin, and a general pale worn-out and listless expression, are frequently to be noted in advanced cases.

Paul Matthews has drawn attention to the occasional presence of skin rashes, erythematous or haemorrhagic, which he has observed in certain cases. The petechial haemorrhages he considers to be due to some haemic condition, the result of dissemination of the tuberculous virus, and to be of grave import.

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[1] *Lancet*, August 5, 1905.

[2] *Brit. Journal of Children's Diseases*, October and November 1906.

The temperature is, as a rule, quite atypical in uncomplicated cases. The supervention of a mixed infection, miliary tuberculosis, or any complication such as meningitis, lateral sinus thrombosis, etc., however, causes marked and notable variations. Where several caseating tuberculous foci are scattered over the body, the temperature chart may assume the "hectic" type.

Local.—In those quite exceptional cases, where the process is acute, the symptoms at the commencement, at any rate, are those of an ordinary attack of otitis media. As the acute symptoms subside and as chronicity is established, the want of reaction, the presence of more than one perforation, the enlargement of peri-auricular glands, and the frequent existence of facial paresis or paralysis serves to indicate the true nature of the disease.

In the majority of cases, however, the pathological process is asthenic from the commencement, the membrana tympani breaking down quite painlessly. The absence of pain is a most notable feature in such cases. In 85 per cent of a series of cases examined by the writer with special reference to the presence or absence of pain, the onset of the disease was apparently quite painless.

The absence of pain is explicable from the extremely slowly progressive nature of the tuberculous lesion in the bone and soft tissues. It is rarely marked, unless there exist a coincidental pyogenic infection which gives rise to acute swellings.

One of the earliest symptoms—the earliest in many cases in the absence of pain—is the presence of a discharge from the middle ear. The discharge is, as a rule, fairly copious, thin, and sanious. It is frequently extremely foetid, owing partly to its source being from diseased bone, and also to secondary infection with putrefactive organisms, *e.g. bacillus butyricus*, *spirochaeta foetida*, etc. At other times it is thick, muco-purulent, and curdy. The presence of blood in the discharge is due to the existence of exuberant granulations associated with osseous lesions.

In acute cases, when perforation has taken place, the membrane appears slightly congested, and the edges of the perforation faintly vascular. There is, however, an absence of that distinct inflammatory reaction invariably seen in cases of purely phlogogenic origin. When more than one tuberculous focus has been formed, more than one perforation may result, while from gradual enlargement and coalescence of various perforations, almost complete destruction of the membrana tympani with exposure of the pars promontoria may ensue. In the more ordinary type of case, which runs a chronic and asthenic course, the membrane appears pale and oedematous, and the edges of the perforations grey, inactive, and flabby. When the greater part of the membrane has been destroyed, the cavity of the middle ear is frequently found full of oedematous granulomatous tissue, which, on microscopic examination, shows evidences of tuberculous changes.

The presence of a perforation in the postero-superior segment of the membrane, unaccompanied by pain or other evidences of inflammatory reaction, is looked upon by certain observers[1] as suggestive of tuberculous middle-ear disease.

Early and extensive involvement of bone is common. In many cases, the bone lesion is complicated with osteomyelitis. So extensive may the destruction of the cancellous tissue of the *pars mastoidea et petrosa* be, that a mere shell of compact bone is left behind. In a case coming under the writer's care, both petrous bones were so eaten away, that only a thin lamina of compact bone was left separating it from the middle cranial fossa. The presence of carious bone is usually very easily demonstrated. Upon probing, areas of rough gritty and softened bone are readily detected, at times covered with soft flabby and oedematous granulations, at other times perfectly bare. In cases where great destruction of the pars petrosa has taken place, the probe may be introduced a distance of from one to two inches without encountering any resistance or causing any pain. Necrosis is also by no means uncommon, large sequestra consisting of the outer attic wall, the cochlea, and portions of the semicircular canal system becoming exfoliated. Such extensive necrosis is due to a superadded acute pyogenic infection.

Destruction of the *ossicula auditus* is also common, either from maceration of their ligamentous attachments, or from an actual tuberculous caries. In fact these bones may be the earliest sites of tuberculosis.

In many cases tuberculous osteo-myelitis involves the pars mastoidea, with consequent erosion of its outer wall, and formation of a subperiosteal abscess. When this is opened, a large fistulous defect is frequently found leading down to the antrum, which is filled with pultaceous debris.

The almost constant presence of destructive processes such as caries or necrosis in tuberculous ear disease serves to explain the frequency with which facial paralysis or paresis is met with. The position of the Fallopian aqueduct renders it readily liable to attack from middle-ear disease, with consequent erosion and exposure of the facial nerve. The resulting perineuritis of the facial nerve may come on quite suddenly, or gradually, and may involve either the whole or a portion of the nerve. In young children it is somewhat difficult to detect minor degrees of facial paresis, owing to the absence of lines or folds upon the face, and owing to their inability to whistle. Clinical investigation shows that facial paralysis is not only much more frequent in tuberculous cases (nearly 65 per cent as compared with 2 per cent in non-tuberculous), but that it is also common at a very much earlier period than in non-tuberculous lesions of the middle or internal ears.

Extension of disease to the internal ear, frequently by way of the fenestrae, or its actual origin in the pars petrosa as a tuberculous osteo-

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[1] Blake and Buck, *N.Y. Med. Journal*, 1806.

myelitis, leads to early implication of its static or acoustic segments. The insidiousness of the process, however, prevents, as a rule, the occurrence of symptoms of the Ménière type. Severe, if not absolute, nerve-deafness is, however, very common. The writer has seen extensive endothelial infiltration of the vestibule without static symptoms.

In primary as also in secondary tuberculous disease of the middle ear early enlargement of peri-auricular glands is practically constant. The parotid, mastoid, and retro-pharyngeal glands are those first involved and subsequently the deep cervical. These various glands may also become matted together by frequently recurring attacks of septic peri-adenitis. In certain cases, glandular involvement is noted before there is any discharge from the middle ear, and before the onset of facial paralysis. The presence of a suppurating sinus near the ear, with pale flabby granulations around its orifice, is strong presumptive evidence of the lesion being tuberculous.

In secondary tuberculosis of the ear glandular enlargement is uncommon, except in those cases where there is a superadded and severe pathogenic infection of the middle-ear tract.

Pathology.—The study of the histology during the early stages of primary tuberculosis involving the tympanic cavity is somewhat limited, partly owing to the subtility of the onset of the disease, and in part owing to its being most probably associated with an attack of suppuration which masks its real nature. Such occurred in the writer's experience, when tubercle bacilli were found in the pus evacuated by paracentesis in an adult who had never previously suffered with ear trouble. Subsequently, however, physical signs of pulmonary trouble, although very slight, were discovered.

The tubercle bacillus is not a pyogenic organism *per se*, therefore, when the discharge is definitely purulent, other bacteria invariably present must be considered responsible.

That many cases are due to direct infection of the tympanic lining by tubercle bacilli there can be but little doubt, neither is it surprising, especially in ears which have been, or are, the seat of simple, acute, or chronic inflammation. For their entrance by the Eustachian tube is so easy, and the facilities for their multiplication are so numerous in the various pockets of the antro-tympanic chamber. Since all parts of the petrous bone have been shown to be subject to tuberculosis at some stage or another of the disease it remains to be proved that the labyrinth is the seat of primary deposit.

The essential feature of a tuberculous lesion, whether of the lining membrane or of the bone, is multiplication of the epithelioid cells (endothelial and perithelial) which completely replace the normal elements of the structure. These foci or "tubercles," being devoid of any attempt to form blood-vessels, die and caseate. Surrounding each epithelioid focus is a widely spreading zone of lymphocytes which wander among the normal elements of the region attacked. One very striking feature is their invasion of the lobules and acini of the glands, which are found in

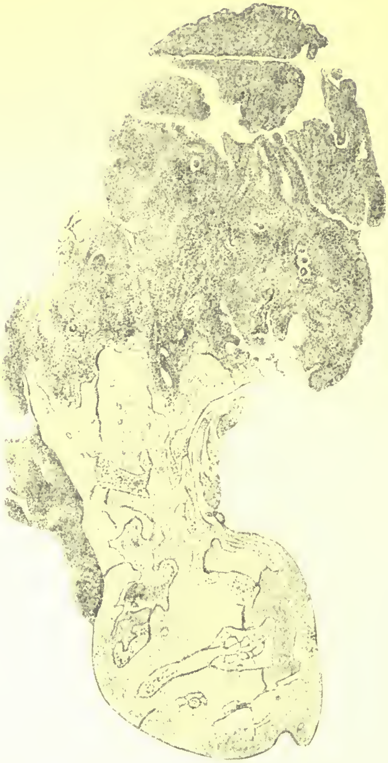

FIG. 132.—Tuberculosis of the Incus.

the neighbourhood of the *ostium tympanicum Eustachii.* Mingled with these epithelioid clusters are giant cells, formed either by fusion or by nuclear multiplication without cytoplasmic division. Tubercle bacilli when present are seen for the most part in the peripheral zone where epithelioid elements and lymphocytes mingle, their presence in giant cells being much less frequent in human than in bovine tubercle. As a rule, "giant-cell systems" without bacilli indicate a slow chronic process, but when bacilli are present in large numbers and giant cells are few the process is acute. When the process is complicated by the presence of pyogenic bacteria, as is practically always the case after perforation and when the mucosa is involved, leucocytes are plentiful, both in the inflammatory focus and in the discharge. Osteoblasts, so active in non-specific septic lesions, are but scanty in numbers, their work being apparently performed in the process of caries by modified endothelial elements, so that although we speak of a tuberculous osteomyelitis, distinction must be drawn between the two forms, however frequently they are in co-operation.

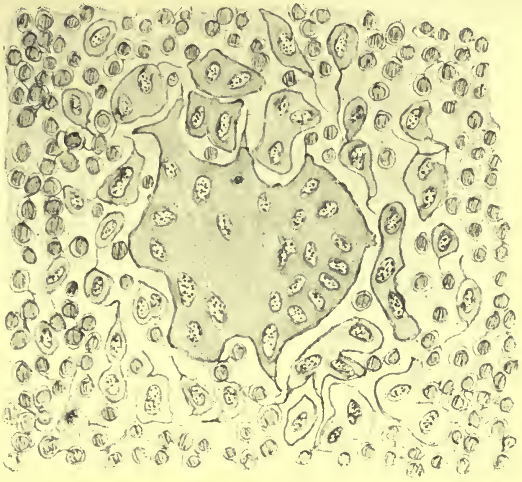

FIG. 133.—Tuberculosis of temporal bone. Obj. $\frac{1}{12}$ in.

Histological sections of tuberculosis, either of the mucosa or of the bone, are identical with that process elsewhere. Figs. 133 and 134 typically illustrate the changes taking place in a mass removed by operation from a chronic case in which the whole antro-tympanic cavity was involved.

Tuberculous discharge from the ear has certain characters of its own. When uncomplicated it is of a thin watery character, containing white or grey granules or flakes—curdy in fact. Lymphocytes are invariably plentiful, while leucocytes are relatively few. Most of the cells are granular, and their nuclei pale and fragmented. Epithelioid cells are well marked, while giant cells may be found if collected directly from a tuberculous area. Such a discharge is but slightly foetid, and when granulations are profuse and when the infective process is mixed, leucocytes and lymphocytes are abundant, while many varieties of bacteria will be found in addition to tubercle bacilli, which are plentiful only in acute cases.

Some difficulty may arise in definitely identifying the bacillus of tubercle, owing to the fact that other acid-fast bacilli are so often present in chronic aural discharge, such as certain streptothricial forms, the *bacillus subtilis, bacillus butyricus,* and *clostridia.* These, however, differ from the bacillus of tubercle, not only morphologically, but by their staining properties. They may be acid-fast from such a source but yield the fuchsin when washed in alcohol, which the tubercle bacillus does only after a prolonged soaking. Tubercle bacilli are colour-true. Other acid-fast bacilli are not, since they give a polychromatic reaction to the Ziehl-Nielsen stain.

A large variety of bacilli found in the ear assume the acid-fast property, due probably to the presence of butyric acid, a product of decomposition, which gives the characteristic foetor to the discharge. It must not be forgotten that old epithelial squames are markedly "acid-fast," and their fragments might easily be mistaken for tubercle bacilli by an inexpert observer in a faulty preparation, or when examined with an inappropriate lens.

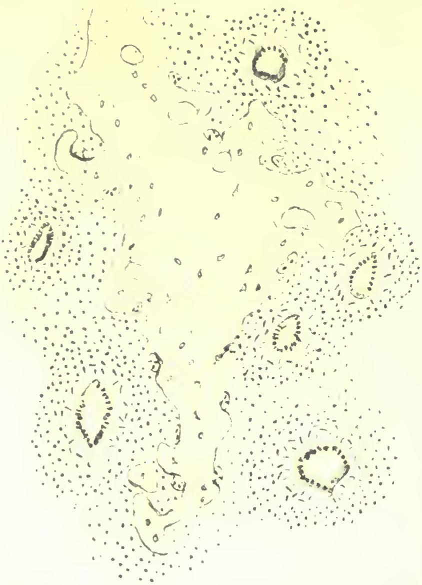
Fig. 134.—Tuberculosis of temporal bone. Obj. $\frac{2}{3}$.

Diagnosis.—A diagnosis of aural tuberculosis is by no means always easily made. Certain clinical signs and symptoms, such as the painless onset of suppuration, the presence of two or more perforations of the membrana tympani, the early appearance of facial paralysis, and enlargement of peri-auricular glands, is strong presumptive evidence of the tuberculous nature of the disease. To verify the diagnosis it is, however, necessary to discover tubercle bacilli in the discharge from the middle ear, or in tufts of granulation tissue or areas of diseased bone removed or exfoliated, bearing in mind that tubercle bacilli are rare in a chronic case but numerous in an acute one.

The bacillus tuberculosis was first discovered in discharge from the ear by Eschle,[1] and has since been frequently found by other observers. It is, however, admittedly difficult to detect, partly because of the small number which may be present in any given case, and partly also from the presence of other acid-fast bacilli. In addition, the bacillus, frequently distorted and somewhat broken up, is difficult to distinguish from other acid-fast bacilli. In an analysis of one hundred specimens of aural discharge Wingrave[1] found acid-fast bacilli twenty-four times, seventeen of which were presumably tubercle.

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[1] *Deutsche med. Wochensch.*, 1883.

In certain cases definite information may be obtained by a careful examination of small fragments of granulation tissue removed from the tympanum. Such tufts show at times evidences of active changes, *e.g.* giant cells, areas of caseation, tubercle bacilli, etc.

Valuable evidence is also obtained from von Pirquet's cuti-reaction in suspected cases. That a positive reaction is obtained does not, of course, establish the fact that the middle-ear lesion is tuberculous, as tuberculous foci may be present in other tissues or organs, to the presence of which the positive reaction is due.

If, however, careful clinical examination has shown other organs to be apparently healthy, the presence of a positive reaction is strong presumptive evidence of the tuberculous nature of the existing ear lesion. The characteristics of a positive reaction: redness, sharp demarcation, infiltration, and the appearance of a papule, with or without surrounding vesiculation, are diagnostic. In 24 cases of asthenic and purulent otitis media in children under ten years of age a positive von Pirquet reaction was obtained in twenty. The tuberculous nature of the lesion was subsequently verified, partly as the result of microscopic examination, and partly from evidence afforded by the inoculation of guinea-pigs with portions of diseased tissue removed in the course of treatment.

The rubbing into the skin of tuberculin ointment (Morro) may be made use of instead of von Pirquet's cuti-reaction, but the results obtained are neither so definite nor so conclusive.[2]

Calmette's ophthalmic test has yielded reliable results.

A more exact and reliable method of diagnosis, but one which is not generally available, is the inoculation of guinea-pigs with portions of bone and granulation tissue removed from the advancing edge of disease. The subcutaneous or intra-peritoneal method of inoculation may be adopted. Both methods yield definite and trustworthy information. In a series of experiments undertaken by the writer guinea-pigs were used, and the subcutaneous method of inoculation was adopted. The animal's left hind limb was carefully shaved, washed with sublimate lotion, and gently singed with a platinum needle at a white heat. A small pocket was then made under the skin at about the level of the knee-joint with a sterile knife, and into this a scraping of bone from an infected temporal bone was introduced with freshly sterilised forceps. The wound was dressed with a sterilised dressing, and the animal returned to its cage. Throughout the whole investigation every care was taken to avoid accidental contamination of instruments or material. Within a fortnight distinctly enlarged superficial inguinal glands were found. Towards the end of the fourth week the ganglia of both fore limbs, and also the cervical ganglia were affected. Five weeks after inoculation the animal was killed and dissected. The accompanying figure (Fig. 135) shows the appearances presented. Besides enlargement of inguinal glands, superficial and deep, the popliteal, the sublumbar, the retro-hepatic, and the peri-bronchial glands upon the same side as the lesion were found markedly enlarged. In addition, the spleen was studded with tubercles, and a few were found scattered here and there in the liver and lung.

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[1] *Journ. of Laryn.*, March 1903.

[2] In v. Pirquet, Morro, and Calmette tests the reaction is doubtless due mainly to the tuberculo-toxins, since all three reactions may prove positive when careful search for tubercle bacilli has failed. This is seen in lupus, which is doubtless an attenuated form of tubercle in which giant cells are numerous, but tubercle bacilli are never found. Further, it must be remembered that in a case of negative result the test must not be repeated for many months.

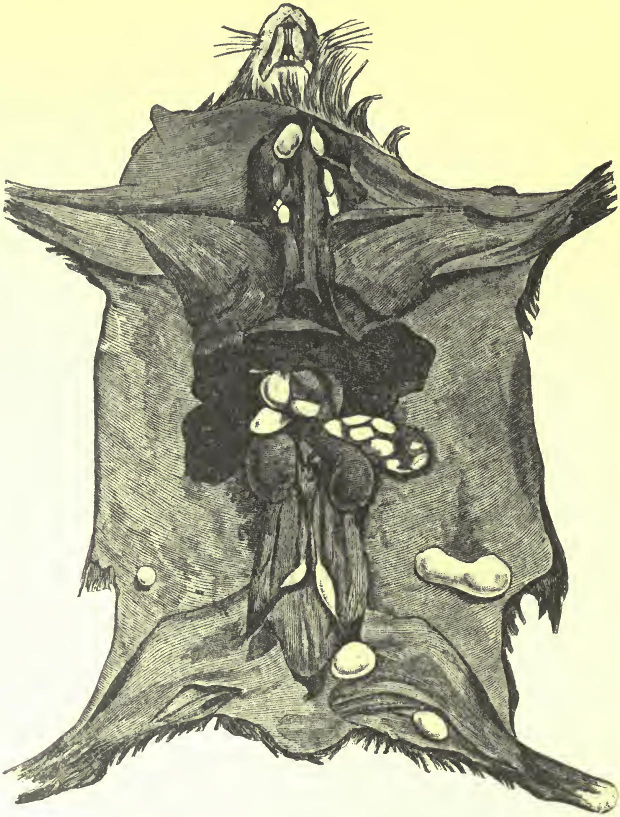

Fig. 135.—Tuberculosis in a guinea-pig, following the inoculation of bone granulation tissue removed from a child suffering from cario-necrosis of the temporal bone (animal killed at end of fifth week).

Scrapings taken from the interior of the sublumbar gland and stained for tubercle bacilli gave positive results.

Grimmer[1] prefers the intra-peritoneal method of inoculation. The tissue for examination, consisting of oedematous granulations and a scraping of bone from the most actively spreading portion of the diseased area, are pounded in a mortar with sterile salt solution and injected with a syringe into the peritoneal cavity of a guinea-pig. The occurrence of an evening rise of temperature following a hard day's exertion is a striking phenomenon in tubercle.

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[1] *Archives of Otolog.*, xxi., 1902.

Treatment.—In the treatment of tuberculous lesions of the ear, the age and general condition of the patient must be carefully considered, as also the primary or secondary nature of the infection.

For convenience of description, cases may be divided into two main groups (1) the inoperable, and (2) the operable.

To the inoperable class belong cases occurring in debilitated infants, where there exist evidences of rapid wasting, extensive temporal bone caries, severe facial paralysis, and copious, blood-stained, discharge. The existence of large masses of tuberculous glands is also a very unfavourable sign.

Cases suitable for operation are those in which the general condition of the patient is good, where the disease is apparently primary, and where its extent does not appear to be beyond the limits of ordinary surgical interference. Also those cases of secondary origin when there are grounds for believing that the removal of tuberculous disease in and around the ear may be fraught with benefit to other existing tuberculous foci. The supervention also of labyrinthine complications is an important indication for operation.

In infants and young children it is preferable to operate by stages, *e.g.* opening up and draining a retro-auricular abscess upon one occasion, and upon another removing carious bone or tuberculous glands.

The underlying idea should be to effect as efficient drainage as is possible, and, where practicable, to remove all infected bone.

As in many cases the morbid process is confined to the temporal bone, this object may be accomplished. No hard and fast line should, however, be drawn, the operator having frequently to perform a quite atypical operation to attain the object in view. When the internal ear has been so extensively destroyed as to obliterate its function, the antrum, tympanum, and infected petro-mastoid cells should be thrown into one large cavity, and every encouragement afforded to enable it to fill up with healthy granulation tissue.

As in many cases the facial nerve also is already, prior to operation, extensively destroyed, attainment of this object is rendered comparatively easy.

The removal of enlarged peri-auricular glands is frequently a matter of great difficulty, but is much facilitated by a primary ligature of the internal jugular vein (Nicol). Before removal of glands the existence of lymphadenoma should be excluded.

In cases where operation is contra-indicated. antiseptic treatment and as complete sterilisation of all pyogenic bacteria as is possible is advisable.

The subcutaneous injection of tuberculin under control of the opsonic index is also worth while trying in chronic focal cases.

In all cases, whether operable or not, fresh air, sunlight, abundance of simple nutritious food, and tonics are essential.

Change of air, especially a prolonged residence at the seaside, is also beneficial.

CHAPTER XXIII

EAR AFFECTIONS IN THE COURSE OF TYPHOID AND OTHER SPECIFIC FEVERS

Aural complications affecting either the middle or internal ear, or both, occur in about 3 per cent of cases of typhoid fever, and usually during the fourth or fifth week of the disease. Bezold, in an analysis of a large number of cases, found, however, that the ear became most frequently attacked from the twenty-fifth to the thirtieth day of the fever.

Inflammation or pyogenic infection of the middle-ear cleft may be due either to extension from the pharynx or naso-pharynx, or to embolic abscesses in the tympanic mucosa secondary to some purulent focus elsewhere in the body. The resulting perforation of the membrana tympani is, as a rule, of large size, and situated in its posterior segment. More than one perforation of the membrane has been noted by Hoffmann, especially in acute cases.

The infection may be primary, or may be superadded to an old active or latent trouble.

As a rule, cicatrisation of the perforation takes place accompanied by a recovery of hearing power. In other cases, however, the suppurative process extends to the mastoid antrum and adjacent mastoid cells, or, owing to erosion of the tympanic or antral roof, intra-cranial suppuration is induced.

The internal ear may also become affected as the result of extension of the inflammatory process from the middle ear (panotitis).

Temporary deafness is frequently present as a consequence of cerebral anaemia, impaired vitality, or profound toxaemia.

Pathology.—Although acute aural troubles are not infrequently associated with typhoid fever, the typhoid bacillus is so rarely demonstrable in the aural discharge that the assumption of a causal relationship rests chiefly upon clinical evidence.

In 3 cases seen by the writer the typhoid bacillus was not found in the discharge at any period of the disease. One case, a male aged twenty-one, was marked by acute suppurative inflammation of the antro-tympanic cavity with a large perforation. The chief micro-organism in the discharge, which lasted for four weeks, was the *bacillus* *coli communis.* The second case was one of primary acute osteomyelitis of the mastoid in a youth of fifteen. In this case the discharge contained the *bacillus coli communis* and large Gram – *diplococci.*

A third case, which terminated fatally from meningitis, was an acute renewal of an old but quiescent chronic suppuration of the middle ear. In this the prevailing micro-organism was the *bacillus coli communis,* while films and cultures obtained from the cerebro-spinal fluid, showed the same organism with a minute Gram – *diplococcus.*

The necropsy revealed no definite channel of infection between the antro-tympanic cavity and the meninges.

As already mentioned, the channel of infection is probably most frequently by way of the Eustachian tube, but that the blood-stream may also be responsible is suggested by the above case of acute osteomyelitis, there being but very slight evidence of tympanic trouble.

Prognosis.—The prognosis, in cases of suppurative and non-suppurative affections of the middle-ear cleft, occurring during the course of typhoid fever, is relatively good, the large size of the perforation favouring efficient drainage from the commencement. When, however, the internal ear is affected, the outlook is much more grave, especially if audition does not materially improve during convalescence.

In many cases permanent deafness and tinnitus remain as the result of degenerative changes in the auditory nerve or auditory nuclei.

Treatment.—Should the general condition of the patient permit, cleansing of the naso-pharyngeal mucosa with an alkaline antiseptic solution is an excellent prophylactic. This may be effected by means of a coarse nasal spray, or by the application of an antiseptic pigment.

In the event of suppuration taking place from the middle ear, free drainage, if not already present, should be effected by incision of the membrane, and antiseptic treatment instituted.

Mastoid and intra-cranial complications should be treated on ordinary principles.

When the internal ear is implicated, the administration of strychnia, phosphorus, or arsenic is, at times, of value. In 3 cases of severe post-typhoidal internal ear deafness coming under the writer's care, the subcutaneous injection of nitrate of pilocarpine effected a considerable improvement.

As a complication of measles, otitis media, both suppurative and non-suppurative, is by no means infrequent. In the writer's experience the exudative type of catarrhal middle-ear disease is distinctly common, and is frequently overlooked owing to the absence of marked symptoms.

The suppurative type, although less severe than the scarlatinal-diphtheritic form of otitis media, simulates it at times and is characterised by destruction of tissue, profuse discharge, invasion of bone, and marked impairment of hearing. It may come on at the commencement of an attack of measles or during the period of desquamation.

Treatment.—Free incision of a swollen and congested membrane is called for, followed by frequent irrigation and the instillation of antiseptic solutions. Small perforations should be enlarged, and when all acute symptoms have subsided, inflation with the air douche regularly practised.

Influenzal Otitis Media.—Both purulent and non-purulent inflammation of the middle ear is common in influenza. The former is extremely prone to lead to invasion of the mastoid cells and to their extensive destruction.

In the early stage of either form of disease haemorrhagic bullae are frequently seen upon the surface of the membrana tympani, more especially in its posterior segment. These bullae in course of time rupture and discharge their sero-sanguineous contents into the external auditory meatus. When perforation takes place it is frequently in the immediate neighbourhood of these bullae, and is prone to be minute and nipple-shaped.

Symptoms.—The characteristic symptoms of suppurative otitis media in influenza are the persistence of pain even after rupture of the membrane has taken place and the tendency to invasion of the apical mastoid cells.

The pain, which is of a neuralgic type, frequently persists after all suppuration has ceased. Tinnitus of a rushing, beating, pulsating, or roaring character is common, and is often persistent in those cases in which extension to the labyrinth has taken place.

Deafness of a more or less aggravated type is also common, and may result from pathological changes in the middle or internal ear, or in both.

Scarlatinal-Diphtheritic Suppuration of the Middle Ear.—As a rule scarlatinal-diphtheritic suppurative middle-ear disease commences during the acute stage of a naso-pharyngeal diphtheria. It is ushered in by severe and often alarming symptoms, especially amongst children. There is a rapid rise of temperature (102° F. to 105° F.), accompanied by early rupture of the membrana tympani, profuse discharge, and by persistent pain. The pain is peculiar in that it persists even after extensive destruction of the membrane has taken place. The amount of destruction of tissue may be very great, in many cases from $\frac{2}{3}$ to $\frac{3}{4}$ of the membrana tympani disappearing within a few days of the onset of the disease. In addition, deep-seated changes are frequent. Thus it is by no means uncommon to find one or more ossicles exfoliated, the bony walls of the tympanic cavity carious or necrotic, and the labyrinth invaded. Extension to the pars mastoidea is also by no means infrequent as an acute osteomyelitis, followed at times by invasion of the meninges, the lateral sinus, or the brain itself.

In young children delirium and convulsions are not unusual. The cervical lymph glands show a marked tendency to enlarge. Even when all acute symptoms have subsided the resulting suppurative process may run a protracted course and be followed by high grades of deafness. In young children scarlatinal-diphtheritic inflammation of the middle ear frequently results in deaf-mutism.

Symptoms.—From the above description it will be noted that the main *subjective* symptoms are high temperature, profuse discharge, persistent pain, and a varying degree of deafness. The *objective* indications of the disease consist in the presence of a large perforation of the membrana tympani, with or without exfoliation of one or more ossicles, a profuse purulent and at times blood-stained discharge, which is occasionally foetid, and at times by the appearance of true diphtheritic membrane in the cavum tympani or external auditory meatus. When present the membrane presents a wash-leather appearance, is tough, and is only separated from the underlying soft tissues with difficulty. Its separation is also accompanied by slight haemorrhage. In those cases where extensive destruction of the membrana tympani has taken place the tympanic mucosa will be seen to present an intensely livid appearance, and frequently to be granular or polypoid.

Prognosis.—The prognosis of scarlatinal-diphtheritic inflammation of the middle ear is, as a rule, unfavourable, extensive destruction of tissue and extensive loss of hearing usually resulting. The disease is prone to be more severe and the prognosis consequently more grave in weakly and anaemic children, and especially when post-nasal adenoids are present.

Treatment.—In addition to general measures and the use of an antitoxin, energetic antiseptic treatment is called for. Early and free incision of the membrana tympani should be at once resorted to and every facility afforded to secure efficient drainage. In the acute stages of the disease inflation should not be employed, but later on in the more quiescent period it is an important adjuvant.

The ear should be irrigated with sterilised warm water or lime water and instillation of boracic acid and alcohol, perchloride of mercury and alcohol, or peroxide of hydrogen made three or four times daily.

Involvement of the mastoid cells, as evidenced by local pain, swelling or redness of the superimposed soft tissues, and by an increase in the amount of discharge calls for an immediate removal of the mastoid cortex and the provision of free drainage.

CHAPTER XXIV

FATAL HAEMORRHAGE FROM THE EAR

Fatal Haemorrhage from the Ear.—Fatal haemorrhage from the ear may be due to an erosion of the internal carotid artery in its passage through the pars petrosa, or to erosion of the bulb of the internal jugular vein, which at times projects through a dehiscence in the floor of the tympanum into the middle ear, and has been wounded during the performance of a paracentesis. Luckily, either accident is distinctly rare, since not more than twenty cases have been recorded in literature.

In all the reported cases of arterial haemorrhage a fatal result has followed in from a few minutes to thirteen days.

In every case of arterial haemorrhage the wall of the internal carotid artery was found softened and perforated at the junction of its vertical with its horizontal portion, a slit-like aperture with irregular jagged edges being discovered.

In most of the cases a long-continued otitis media purulenta had existed, followed by extensive caries and exposure of the carotid artery.

The arterial walls, bathed continuously in pus, become softened, and, from sudden increase of arterial pressure, rupture. In several of the recorded cases, tuberculosis of the temporal bone existed; in one the underlying lesion was syphilitic, and in a case recorded by Sokolowsky[1] the erosion is stated to have occurred from cauterisation with an acid.

In two cases coming under the writer's observation the cause in one was chronic tuberculosis of the temporal bone, and in the other malignant disease spreading from the auditory meatus to the internal ear.

In the first case, a child, death took place after the fourth attack of haemorrhage, which occurred upon the seventh day; in the second case, a man aged fifty-two, a fatal result followed in a few hours.

The first attack of bleeding may not be very severe, but each succeeding attack is worse than the former. The blood may spurt out with great force. If dammed up by the insertion of a plug in the meatus it either forces the plug out, or, if unable to do so, pours down the Eustachian tube into the naso-pharynx. In one recorded case, it spurted out from a fistula in the mastoid cortex.

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[1] *Centralblatt für Chirurgie*, 1881.

In Pilz's case, where the membrana tympani was intact, the blood forced its way through a fistulous opening in the tympanic floor into an abscess cavity in the pars petrosa, and finally into the pharynx. In Halász's case,[1] blood began to trickle slowly from the right ear of an infant aged two weeks. A haematoma formed under the sterno-mastoid muscle. The infant died eight days after the onset of the haemorrhage.

Symptoms.—In cases of arterial haemorrhage, the blood is bright-red in colour, and may be ejected in spurts from the ear. It has occasionally been found mixed with pus. When, however, the haemorrhage comes from the internal jugular vein it is of a dark colour and flows rather than spurts. The flow is increased by pressure upon the jugular vein, and its oscillations are synchronous with the movements of breathing. The amount lost may be so great as to produce rapid syncope if not death. Blood may escape from the meatus, nasal passages, and mouth at one and the same time if the Eustachian tube is patent, or if a fistulous tract leads into the naso-pharynx.

Repeated attacks induce profound anaemia and prostration. Pain is seldom if ever complained of.

In cases of arterial haemorrhage pressure upon the carotid artery causes the flow to cease, whereas should the bleeding be from the jugular bulb it produces no effect.

Arterial haemorrhage may also proceed from branches of the internal carotid or from the middle meningeal artery. In both cases the flow is very much less than if coming directly from the internal carotid itself. Digital pressure over the vertebral artery may control the flow temporarily if it is from one of its radicles to the internal ear.

Prognosis.—Prognosis is exceedingly bad, all the reported cases having proved fatal.

Treatment.—As a temporary measure the meatus should be firmly plugged with gauze and pressure made upon the common carotid artery. In severe attacks the plug is rapidly forced from the ear by the *vis a tergo*, while free bleeding takes place *per tubam*. Continuous pressure upon the internal carotid artery causes such pain that its maintenance for prolonged periods is practically impossible, hence ligature of the common carotid artery should be undertaken as soon as possible, and the meatus tightly packed with iodoform gauze or with antiseptic gelatine.

When ligature of one common carotid artery fails to arrest the bleeding, the other should be tied. Even in spite of this having been been done haemorrhage has recurred.

Notwithstanding the very unfavourable results so far attained, it is the duty of the surgeon to ligature the common carotid artery in the hope that the thrombus so produced may prevent fresh attacks.

Should the bleeding take place from the jugular bulb a tampon should be inserted into the middle ear, and firm pressure maintained.[2]

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[1] *Archiv für Ohrenheilk.* Bd. 76, Hefte 1 & 2, p. 78.

[2] *Ibid.*

CHAPTER XXV

DISEASES OF THE MASTOID PROCESS

INFLAMMATORY affections of the muco-periosteal lining of the mastoid cells are, as a rule, consecutive to disease of the middle-ear cleft. In exceptional cases, however, an inflammatory process spreads from the osseo-cutaneous walls of the external auditory meatus to the adjoining mastoid area. In cases of furunculosis of the auditory meatus a secondary periostitis of the pars mastoidea is also occasionally observed.

The inflammatory process may attack and may remain limited to the periosteum, or to the endosteum lining the various pneumatic cells of the pars mastoidea, or may extend from the surface to the interior of the bone, more commonly, however, from the interior to the surface, with the production of a sub-periosteal collection of pus.

1. **Periostitis** (*Primary and Secondary*).—Acute *primary* periostitis of the mastoid process is a rare affection. It is a form of cellulitis or erysipelas involving the periosteum, and usually of streptococcal origin. It occurs more frequently in adults than in children, and is due to exposure to cold, injury, forcible pulling of the ear, specific fevers, adenitis of the retro-auricular gland, typhoid fever, mumps, or acute rheumatism. At times no obvious cause is found. It may remain as a localised inflammation, or may spread over the side of the head, producing an amount of solid, brawny oedema sufficient to cause closure of the eyelids upon the affected side. Should it extend downwards towards the apex of the mastoid process, it involves the corresponding sterno-mastoid muscle, with consequent stiff neck and an interference with the movements of the head. Suppuration may or may not result.

2. *Secondary Periostitis* is much more common, and arises as the result of extension of disease, often tuberculous, from the lining of the middle-ear cleft or mastoid cells, or from inflammatory affections of the external auditory meatus, *e.g.* diffuse otitis externa, furuncles, condylomata, foreign bodies in the meatus, etc.

When secondary to suppurative disease within the middle ear or mastoid antrum, the path of infection may be along the fibrous trabeculae and peri-vascular sheaths which ramify between the periosteum covering the process and the endosteum lining its cells, or along the connective tissue strands of the squamo-mastoid fissure so frequently unossified in young children.

Symptomatology.—The signs and symptoms of mastoid periostitis vary according to whether the affection is primary or secondary.

In *primary* periostitis no impairment of hearing is, as a rule, observed, except in those cases complicated by some intercurrent or previous affection of the middle ear, or in which the stenosis of the meatus, induced by prolapse of its postero-superior wall, is so great as to offer obstruction to the passage of sound waves to the membrana tympani.

In cases of *secondary* origin there is invariably some degree of deafness, and, in addition, other symptoms indicative of middle-ear or labyrinthine involvement.

The bodily temperature is elevated, more so if suppuration is about to take place, while the surface temperature of the affected area is always raised.

In all cases there is considerable oedema of the soft tissues, with the result that the auricle is displaced downwards and outwards. This striking asymmetry is best observed when the patient is examined from behind (Fig. 137).

The amount of oedema is so great as to cause at times complete stenosis of the meatus. A concomitant congestion and slight swelling of the membrana tympani takes place under such circumstances.

Fluctuation may be exceedingly difficult to make out at first, owing to infiltration of the superimposed tissues and the intimate connection of the periosteum with the underlying bone; later, however, it becomes well marked.

Course and Terminations.—Under favourable circumstances oedema subsides, and resolution takes place within from four to five days. In other cases a sub-periosteal mastoid abscess forms, and unless promptly opened, discharges externally or into the auditory meatus through one of the fissures of Santorini. In rare cases necrosis of the mastoid cortex results, with exfoliation of a thin sequestrum. This is especially prone to take place in cases of recurring periostitis, and may ultimately lead to perforation and infection of the subcortical mastoid cells.

Diagnosis.—In *primary* cases a diagnosis is, as a rule, easily made from a consideration of the various local appearances, and from the absence of any middle-ear lesion. In recurrent cases, or those running a chronic course, the possibility of intra-mastoid suppuration should be borne in mind, even in the absence of objective indications of middle-ear disease.

In *secondary* cases there is invariably present some inflammatory or infective condition of the lining of the middle-ear cleft or mastoid cells.

An attack of periostitis may be confounded with those painful and localised swellings over the mastoid process occurring at times in conjunction with the presence of deep-seated furuncles in the auditory meatus, with suppuration of a mastoid lymph gland, or with Bezold's mastoiditis.

Prognosis.—The prognosis of *primary* acute periostitis is favourable except in delicate or tuberculous children.

In periostitis of *secondary* origin the prognosis varies with the extent of the initial infection, its causative factor, and the state of health of the individual.

Treatment.—If suppuration has not taken place, efforts should be made to effect resolution by rest in bed and the administration of a saline cathartic, followed by drop doses of tincture of aconite every hour for twenty-four hours.

In the early stages of the disease the local application of cold by means of a specially shaped ice-bag or a Leiter's coil is useful. In some cases the application of heat proves more effective. It may be applied in the form of boracic or acetate of lead and belladonna fomentations, by running a continuous stream of hot water through a Leiter's coil, or in the form of dry heat by means of salt or sand-bags, pads of wool or spongiopiline.

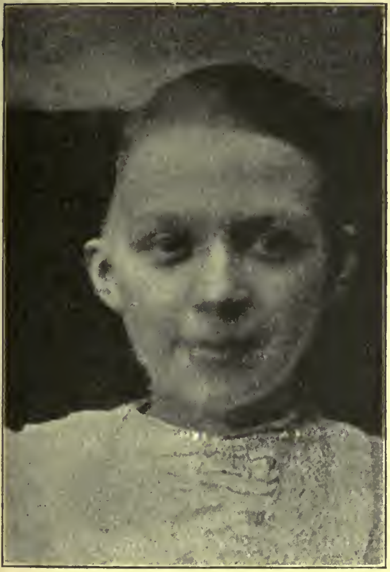

FIG. 136.—Acute suppurative mastoid periostitis (front view).

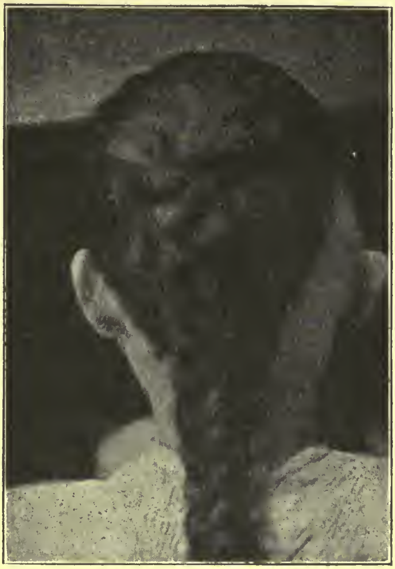

FIG. 137.—Acute suppurative mastoid periostitis (viewed from behind), showing the downward, outward, and forward displacement of auricle.

Local abstraction of blood, either by the application of from two to four leeches over the indurated tissues, or scarification with an artificial leech is particularly useful. Bleeding should be encouraged rather than otherwise, as the relief obtained from local depletion is often very great.

Painting the swollen and indurated tissues with tincture of iodine, or a 5 per cent alcoholic solution of ichthyol, or gentle inunction with a

5 per cent oleate of mercury ointment is at times successful, as is also the local application of a thick paste of aluminium silicate.

When there is marked oedema uninfluenced by the application of any of the previously named remedies, and especially if pain and swelling are increasing, incision of the swelling (Wilde's incision) is called for. The incision should be made from 1 to 1¼ inches long, parallel to and ¼ inch behind the attachment of the auricle. It should be made down to the bone throughout its entire length. When the exudate has not become purulent, subsidence of all inflammatory symptoms rapidly takes place. On the other hand, should pus be present, the abscess cavity should be cleansed, and careful search made for any fistulous tract leading into the mastoid cells. Haemorrhage is at times severe, and may demand ligation of the posterior auricular artery. The process of repair is materially hastened by inserting a few stitches at the time of operation, and by subsequently bringing the edges of the incision together when all oedema has subsided or pus formation has become arrested.

When rupture of a subperiosteal abscess has taken place into the meatus, it may be necessary to enlarge the fistulous tract in order to secure free drainage and to facilitate the introduction of a gauze dressing.

If superficial caries or necrosis of the cortex is present, the incision should be kept open throughout its entire length.

In *secondary* periostitis, associated with chronic suppurative middle-ear disease, fistulae surrounded by oedematous granulations will frequently be found leading down to areas of necrotic bone (Fig. 138). Under such circumstances it is necessary to open up the path of disease, and to eradicate all infective granulation tissue and carious bone.

The effect of incising the indurated periosteum in cases of acute and uncomplicated suppuration of the tympanic mucosa is remarkable, subsidence of inflammation followed by cicatrisation of the existing perforation rapidly taking place.

Graduated pressure by the application of an elastic bandage over the ordinary external dressings is useful in maintaining close approximation of the superficial soft structures to the underlying bone.

Internally, one minim doses of tincture of aconite repeated every hour for twelve hours, salicylate of soda (gr. x. to xv.), or aspirin (gr. v.) four times daily are useful.

3. **Acute Primary Inflammation of the Mastoid Cells.**—Acute primary inflammation of the lining of the mastoid cells is rare, although it sometimes makes its appearance after an acute middle-ear suppuration has run its course. It may also be due to injury, cold, or secondary infection from the naso-pharynx. It is sometimes associated with the exanthemata, occurring most frequently in pneumonic processes, and generally attacking those mastoid cells which are situated posteriorly and inferiorly, although it may ultimately spread over the whole mastoid area. It seldom attacks diploetic mastoids, except in children.

Pathology.—Although inflammation of the mastoid cells is for the most part attended by disease of the antro-tympanic cavity, it is occasionally so pronounced as to overshadow the middle ear symptoms to such an extent as to justify its consideration as an independent and primary disease.

It may be somewhat arbitrarily divided into two forms, one in which the changes are confined to the pneumatic cells, and for the most part catarrhal in character; the other, which is of much greater intensity, purulent in type and involving primarily the diploic tissues.

Catarrhal Type.—The catarrhal form occurs most frequently during adolescence, or when the apical cells are exceptionally pneumatic. It is marked by epithelial proliferation, and a small amount of leucocytic exudation, which is subsequently absorbed.

There may be much hyperaemia, but the bone itself is not seriously involved. This is a relatively mild infection through the Eustachian tube, associated with a Gram – diplococcus (*diplococcus catarrhalis*) *bacillus septus* (Cautley's bacillus), and rarely with Pfeiffer's influenza bacillus.

Purulent Type.—The purulent type is, however, of far greater intensity, and is attended by rapid absorption of the cancellous bone, and by extension to the surface. The various changes are not confined to the lining of the pneumatic spaces, but chiefly involve the diploic tissue constituting acute osteomyelitis, associated with the more virulent and pyogenic bacteria—*streptococci*, *pneumococci*, *diplococcus meningitidis*, and *staphylococci*, etc.—which may have been conveyed either by the Eustachian tube or by the blood stream.

The pus contains, in addition to granular leucocytes and bacteria, large numbers of mono- and polynucleated myelocytes and osteoblasts.

In children the rapidity and intensity of the osteomyelitis is such that the greater part of the mastoid may be sequestrated in a few days. Between these extreme types many intermediate degrees will be found.

Further, acute infection of the mastoid cells has been traced to a local tuberculosis of the bone, which becomes the seat of suppuration from a superadded invasion by pyogenic bacteria, either through the antro-tympanic cavity, or through the blood stream in the course of an acute infectious fever.

Symptoms.—There is severe local pain, with at first no evidence of swelling or oedema. The nearer the surface the inflammatory process is situated, the earlier the external indications of its presence. The development of a secondary periostitis is by no means unusual. Should the inflammatory process proceed to suppuration, pain becomes much more severe, is greatly increased on pressure, and is accompanied by high fever. External indications of the presence of suppuration are swelling and oedema of the superimposed soft tissues, accompanied by an outward and downward displacement of the auricle and torticollis. When situated superficially the abscess usually breaks through the cortex or through the fissura mastoidea squamosa, producing a subperiosteal collection of pus.

Course and Terminations.—In acute cases the course of events is rapid, the inflammatory process lasting for from six to eight days, and then subsiding without the formation of pus. Should it, however, go on to pus formation, erosion of the cortex, with formation of a subperiosteal abscess or rupture into the meatus, results. Rupture through the mesial mastoid wall, with the development of an abscess under the deep cervical fascia (Bezold's mastoiditis), rarely takes place. When the abscess discharges spontaneously a fistulous track is formed which may remain open for weeks or even months. In those cases where the intra-mastoid inflammation has spread and has involved the cavity of the middle ear, with or without perforation of the membrane, the course of the disease is apt to be protracted.

Diagnosis.—A diagnosis of acute primary inflammation of the mastoid cells is made from the presence of severe and continuous local pain, accompanied by fever and by subsequent oedema of superimposed soft tissues, but unaccompanied by any evidence of middle-ear inflammation. Should superficial abscess formation have taken place at the time of the first examination, it may not be possible to differentiate the case from one of acute suppurative periostitis, whilst, should the inflammatory process have invaded the antro-tympanic cavity, it is impossible to say definitely whether it is a primary or a secondary involvement of the mastoid area.

Prognosis.—The prognosis is good in acute uncomplicated suppuration of the mastoid cells, complete healing with restoration of hearing power taking place in almost every case, provided that the middle ear is adequately drained, and all infected mastoid cells removed. The prognosis in chronic suppuration of the mastoid cells, so far as the cessation of suppuration is concerned is also good, if no intracranial complication or extension to the labyrinth is present, and provided that a complete post-aural operation has been performed.

The prognosis, so far as hearing, when affected early in the course of the disease, is, however, always a matter of some doubt. In many cases, the removal of infected cells and of granulation tissue from the middle ear, and the consequent arrest of suppuration, is followed by improved audition. In other cases, however, owing either to post-suppurative adhesion of the stapes to the margins of the *fenestra ovalis*, or to implication of the terminal auditory nerve filaments, no improvement in hearing results, while in yet others, owing to cicatricial contraction, or to condensation of the epithelium lining the healed cavity, audition is actually worse than before operation.

The prognosis is less favourable in anaemic, tuberculous, and elderly people, and in those cases where great disorganisation of the middle ear has previously taken place. The presence of labyrinthine or intra-cranial suppuration naturally modifies the prognosis according to its site, duration, and extent.

Treatment.—Before suppuration has taken place local depletion, antiphlogistic treatment, or a Wilde's incision is called for. The formation of an abscess in the bone demands removal of a sufficient amount of cortex to enable it to be thoroughly cleared out and surgical drainage effected.

4. **Acute Purulent Inflammation of the Mastoid Cells.**—*Secondary.*—In every case of acute purulent inflammation of the muco-periosteum lining the middle-ear cleft pus will be found in its posterior end—the mastoid antrum—and often in the adjacent pneumatic spaces of the mastoid process. This is in part due to the continuity of these spaces, and also to the fact that when the patient is recumbent pus gravitates towards the mastoid area. The antrum may, under such circumstances, act as a reservoir for accumulating secretion, while, provided that no retention or reinfection takes place, resolution may result without the development of any mastoid symptoms whatever. On the other hand, should retention of secretion be brought about, either by swelling of the mucosa of the *iter ad antrum*, or of the lining of the pneumatic cells communicating with the antrum, or should the bony trabeculae between individual cells in chronic cases become infected, an acute mastoid empyema is produced.

Factors, which contribute to extension of inflammation from the tympanic cavity to the mastoid cells are catching cold, exposure, influenza, scarlatinal diphtheria, the exanthemata, typhoid fever, tuberculosis, diabetes, and syphilis. In influenza (*la grippe*) there is a peculiar liability to the formation of sub-cortical apical abscesses. Certain local conditions, such as insufficient drainage of pus from the tympanum owing to the presence of a too small or too highly situated perforation of the membrane, or of granulation tissue, are common factors in the production of acute suppurative endomastoiditis. Pneumatic mastoid processes are much more frequently affected than diploetic, while abscess formation does not occur in the vertical portions of a compact process.

Symptoms.—Acute purulent infection of the mastoid cells may occur before, although more usually after, perforation of the membrana tympani has taken place. The earliest indication of its presence is pain, at first local, but soon radiating over the side of the head. This pain, of a deep-seated and boring character, is, as a rule, increased by percussion and invariably by pressure, the most sensitive area being the tip of the process, its anterior wall, and immediately over the antral area. At the same time there is a rapid rise of temperature, especially in children, in whom it may reach 104° F. to 106° F., with quick pulse, and other febrile phenomena. The surface temperature of the affected region is always raised. In many cases this acute inflammatory attack subsides without the formation of an abscess, or it may end in a collection of pus generally in the sub-cortical and apical cells. Resolution is prone to take place in simple catarrhal infection of the middle-ear tract; abscess formation in those due to influenza, the exanthemata, syphilis, and diabetes.

In its early stages several small localised and discrete abscesses may form, which later become confluent and form one abscess cavity, situated almost invariably in the lower and vertical part of the process, and usually sub-cortically. The formation of such an abscess cavity may be recognised by :—

1. A marked increase of pain, which is, as a rule, constant, local, and situated over the purulent collection, but which may also be diffuse and intermittent.

2. Elevation of the surface temperature of the part as compared with that of the opposite side.

3. Elevation of bodily temperature. This is, however, by no means constant, many chronic and tuberculous abscesses developing with a normal or practically normal temperature.

4. Increase in the pulse rate.

5. Swelling, oedema, and redness of the skin covering the mastoid process. The more superficially situated the purulent collection is the more rapidly do external evidences of its presence manifest themselves. Even large abscesses, if deeply seated, may cause no alteration in the soft tissues covering the process. The persistence of the infantile type of temporal bone (Cheatle) also prevents suppuration reaching the surface.

6. A downward and outward displacement of the auricle, best seen when the patient is viewed from behind.

7. Torticollis.

8. Bulging of the posterior segment of the membrana tympani, with at times the presence of a nipple-shaped perforation.

9. Sagging of the postero-superior meatal wall in the immediate vicinity of the membrana tympani.

10. The presence of a more or less profuse discharge. This is, however, not a constant symptom, as many cases exist where discharge from the middle ear has entirely ceased, and the perforation has healed, whilst abscess formation is going on in the mastoid cells. The presence, however, of a discharge which persistently reappears after carefully drying the membrane with a cotton-tipped probe is strong evidence of the presence of an intra-mastoid collection of pus, the deduction being that it is oozing from some reservoir, *e.g.* the mastoid area, the amount of the flow being much greater than could be accounted for if the middle ear alone were the part solely affected. The line of flow has also a certain practical significance. Thus, if it proceed from the mastoid antrum its flow takes place *in a single line over the inner wall of the cavity* from the postero-superior to the postero-inferior segment, passing, when the head is held vertically, in front of the fenestra ovalis and fossula rotunda. If generated within the epitympanum, its flow is diffuse, and over the inner wall of the middle ear.

11. Facial paresis or paralysis. This is not a common symptom of acute suppurative endomastoiditis, but may occur in cases of influenzal, tuberculous, or exanthematous origin, or in panotitis. It is probably due to a neuritis occurring as the result of the preceding or accompanying inflammation of the middle ear, and in the writer's experience, more especially in cases of acute epitympanic suppuration.

Pathology.—As already mentioned acute suppuration, or abscess of the mastoid element, may occur as a primary disease, but more commonly in connection with acute infection of the antro-tympanic cavity. As an independent and primary affection the diploic bone is chiefly involved as an acute osteomyelitis, but in this form the pneumatic spaces are specially attacked either secondarily to or coincidentally with infection of the adjacent cavity.

Infection may be acute and fulminating from the first, or may become acute when grafted on a chronic basis, and its effects will depend upon three conditions :—

1. Age of patient and stage of development of the mastoid element.
2. Extent and nature of any pre-existing disease of the middle ear.
3. Intensity of the infecting virus.

It may be limited to the apical and cortical cells, or may involve the deeper cells. There is, however, always a certain amount of diploic involvement and osteomyelitis, especially in early life.

Sequestration of large areas of bone is generally associated with syphilitic conditions in adults, but not necessarily so in children, being in them due to fulminating osteomyelitis.

A pre-existing tuberculosis predisposes to necrosis and sequestration, but in the event of an abscess forming in connection with an old and long-standing case of chronic suppuration of the middle ear, there will only be burrowing of pus in the direction of least resistance, with the formation of a fistula. Extensive exfoliation is therefore rare, there being expansion of the cells, with dense eburnation of their walls, and cholesteatomatous formation.

The morbid changes begin by intense hyperaemia of the endosteum lining the pneumatic spaces, extending to the bony channels, and subsequent blocking of the vessels. Swelling and desquamation of the lining epithelium is rapidly followed by exudation of leucocytes and multiplication of the mono- and multinucleated osteoblasts. These cells die and produce trypsin, which erodes all adjacent structures, and forms an abscess cavity. Caries, or necrosis of the adjacent bone, follows in accordance with the intensity of the infection, and the density of the bone.

The immediate exciting cause is a pyogenic organism, behaving either as a primary infection, or superadded to a pre-existing chronic process, or often in connection with a specific fever.

In the event of a primary infection, the bacteria found in the pus, although numerous, are few in variety, exactly the reverse of that occurring in a grafted process, when the varieties are numerous.

The micro-organisms most frequently met with are :—

Streptococcus.
Diplococcus Pneumoniae.
Diplococcus Catarrhalis.
Staphylococcus.

Less frequently—

Diplo-bacillus of Friedlander.
Klebs Loeffler Bacillus.

Pfeiffer's Influenza Bacillus.
Bacillus Proteus Vulgaris.
Bacillus Pyocyaneus.
Bacillus Septus (Cautley).

The diplococcus catarrhalis (Gram −) was the sole organism found in 8 cases, while the diplo-bacillus of Cautley occurred with other bacteria in 7 cases. The bacillus pyocyaneus occurred only in abscesses following old chronic disease of the antrum, where varieties of streptothrix are by no means rare.

In tuberculous cases, the pus may find openings in many directions, in 1 case of the writer's—that of a girl of seventeen—it not only extended into the sheath of the temporal muscle but, piercing the squama, formed a large, temporal abscess, limited above by the temporal ridge, with extensive exfoliation of the *squama-temporalis.*

A striking instance of streptothricial abscess of the mastoid was that of a man aged 27, a patient of Mr. Chichele Nourse, the subject of an old-standing, quiescent suppuration of the middle ear. He was attacked by an acute mastoid abscess which rapidly destroyed a large area of the mastoid bone, complicated with profound septicaemia, from which he died, thirteen days after the onset of the acute symptoms. The pus, both before and after the operation, contained only streptothrices in large numbers, chiefly acid-fast, and although, when seen separately, having a striking morphological resemblance to tubercle bacilli, when viewed collectively as felted masses, and not being alcohol-fast, were readily distinguished from them. Necropsy revealed no extension of the disease beyond the antrum and mastoid cells.

Terminations.—The various terminations of acute suppurative endomastoiditis are:—

1. Resolution after absorption of pus has taken place, and disappearance of morbid changes in the mucosa.

2. Formation of an abscess, which may either become completely absorbed with subsequent obliteration of the cancellous spaces of the mastoid process, or which may—

3. Gradually work towards the surface, erode the cortex, and produce a sub-periosteal abscess, with or without the formation of a fistula through the skin. This termination is especially prone to occur in children (Fig. 138).

4. Perforation of the posterior meatal wall.

5. Perforation of the median mastoid table (Bezold's mastoiditis).

6. Perforation of the posterior mastoid table with formation of a peri-sinusal abscess, with or without thrombosis of the lateral sinus.

7. Perforation of the outer labyrinthine wall, followed by circumscribed or diffuse pyo-labyrinthitis.

8. Perforation of the antro-tympanic roof or the triangular plate of bone upon the posterior surface of the pars petrosa, with the development of such intra-cranial lesions as meningitis, extra or subdural abscess, cerebral or cerebellar abscess.

9. Retropharyngeal abscess.
10. Sequestration of the *pars petro-mastoidea.*
11. Diffuse temporal abscess.
12. Suppurating sinuses.
13. Parotid abscess.
14. Suppuration extending along the digastric muscle or occipital artery to the suboccipital planes of connective tissue.

Prognosis.—Prognosis is, as a rule, favourable, and depends mainly upon the underlying cause and the duration of the disease. The earlier the purulent focus is recognised and drained the more rapid the healing, whilst the longer the disease lasts the greater the destruction of adjacent tissue, and the greater the liability of extension to vital organs. The prognosis is also better in mixed pyogenic infections than in those occurring during the course of the exanthemata, enteric fever, influenza, tuberculosis, and diabetes.

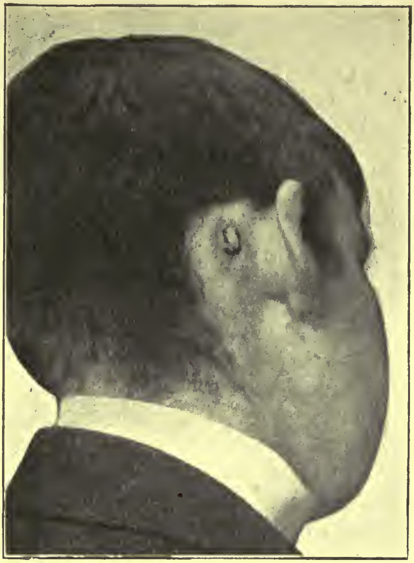

FIG. 138.—Mastoid fistula surrounded by bone granulations from a case of chronic purulent otitis media.

Treatment. — In the early stages of acute purulent endomastoiditis, resolution may be brought about by the employment of antiphlogistic treatment, combined with free drainage of the middle ear, and the use of antiseptics. Rest in bed, in a warm, well-ventilated room, a light diet, and the administration of saline aperients assist materially in inducing resolution and healing. To obtain efficient drainage from the infected middle-ear cleft, the inflamed and bulging membrane, if not already ruptured, should be freely incised, vertically or horizontally, while a small perforation, if present, should be enlarged so as to secure free and unimpeded egress for all inflammatory products. In addition, aspiration either by means of a Sondermann's apparatus or Siegle's pneumatic speculum, assists recovery by withdrawing exudation, abstracting blood, and causing a flow of anti-bactericidal serum over the inflamed tympanic mucosa. A flow of lymph may be further induced by irrigation and packing with Wright's hypertonic solution—sodium chloride 4 parts, sodium citrate 1 part, sterilised water 95 parts.

Energetic antiphlogistic treatment is also called for in the early days of the inflammatory process, and is effected by the application of from 4 to 6 leeches, the number varying with the acuteness of the process around the ear and the age of the patient, or by scarification with Heurteloupe's artificial leech, or Delstanche's aspirating syringe.

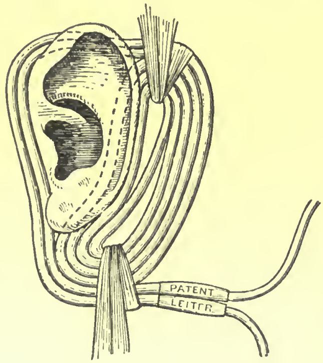

FIG. 139.—Leiter's coil (for hot or cold water) applied to the ear.

The application of cold, either by means of a specially-shaped ice-bag, or by running iced water through a Leiter's apparatus (Fig. 139) or Gärtner's modification of the same, is of value, not only in relieving pain and arresting inflammation, but also in indicating the progress of events. So long as the apparatus is well borne the inflammatory process is probably advancing, whereas, should its application be irritating or painful, we may conclude that it is subsiding. The application of counter irritants or vescicants over the mastoid process is best avoided, tending as they do to mask symptoms, and to irritate the skin, which may have subsequently to be incised. Should antiphlogistic treatment fail to arrest the inflammatory process within from two to three days of its onset, it is advisable that operative treatment be adopted at once. It is infinitely better, if any doubt exists, to operate at an early stage of the disease than to allow progressive destruction of the cancellous tissue of the mastoid process and the contents of the tympanum to proceed unchecked, the more so if the endomastoiditis be due to the exanthemata, influenza, or diabetes. Whether complete ablation of all the mastoid cells be called for or not can only be determined after removal of the cortex.

In many cases the abscess cavity is found to be localised, subcortical, or apical, and all that is required in such cases is removal of overhanging bone and the establishment of free drainage. In other cases it is necessary to lay open the mastoid antrum, and to scrape out the whole cellular contents of the process, even extending the investigation forwards into the zygomatic area.

The Operation for Acute Suppurative Endomastoiditis.—*Preliminary Preparation.*—The head should be well washed the night before operation, thoroughly dried, and the hair, for an area of at least 4 inches round the ear, shaved off.

Two hours before operation the skin should be painted with a 2 per cent solution of iodine in rectified spirit or chloroform, and a pad of sterile gauze applied. When the patient is under the influence of the anaesthetic the iodine solution should again be applied to the operation area.

An incision is made $\frac{1}{4}$ inch behind and parallel to the attachment of the auricle from the centre of the mastoid apex to its base upon the left side, and from its base to the centre of its apex upon the right side (Fig. 140). The incision is carried down to the bone throughout its entire length and all bleeding points are ligated. With an elevator the periosteum and soft tissues are gently but firmly pushed forwards until the posterior border of the bony meatus and Henle's spine are seen. In a similar manner the periosteum and soft tissues are pushed backwards until the whole surface of the mastoid process is exposed to view. In cases where the superimposed soft tissues are thickened and oedematous, it may be necessary to make another incision at right angles to the centre of the former, and extending backwards for about an inch in order to secure free access to the underlying bone. The lips of the wound are now held open with a broad rake or self-retaining retractors (Jansen, Allport, Milligan) (Fig. 141), which have the further advantage, by the pressure they exert, of tending to arrest oozing from the cut surfaces.

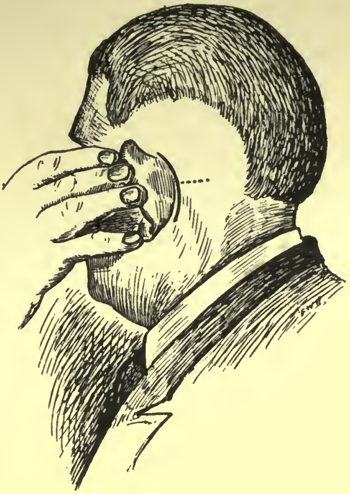

Fig. 140.—The post-aural incision (Wilde's).

Should haemorrhage from small bleeding points prove troublesome the wound may be douched with hot sterilised water, or covered for a few moments with a piece of lint soaked in sterilised 1 to 1000 adrenalin solution. A careful scrutiny of the various landmarks should now be made, viz. the posterior edge of the bony meatus, Henle's spine, the supra-meatal triangle (MacEwen) and the posterior root of the zygoma (Fig. 145). A broad and well-developed mastoid is, as a rule, pneumatic in structure, and indicative of a normal position of the middle fossa and sigmoid sinus, while a narrow and elongated process is generally diploetic, and associated with a low middle fossa and a forward sinus.

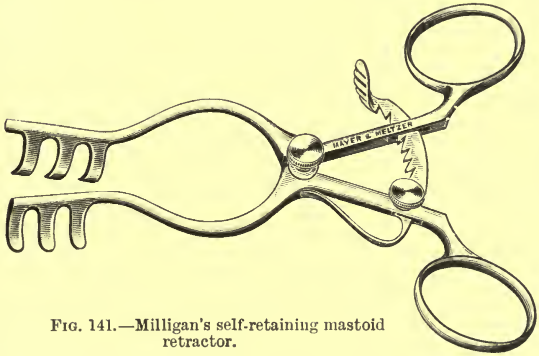

Fig. 141.—Milligan's self-retaining mastoid retractor.

The mastoid cortex should now be removed layer by layer with gouge and mallet, or as advocated by some operators, with a gouge, working always in a direction towards and parallel to the posterior wall of the auditory meatus. In this way it is possible to see exactly what is being done, and to avoid injury to the knee of the sigmoid sinus should it happen to lie unduly far forwards or to be unusually superficial in position.

The various gouges and cutting instruments used throughout the operation should be highly sharpened and well "tempered" so as to avoid as far as is possible excessive use of the mallet. During the removal of the cortex the bone should be kept dry by frequent mopping with small pieces of sterilised lint, and frequent use made of the probe to examine the underlying condition. In addition the field of operation should be kept well illuminated by a beam of light reflected from a limelight apparatus or powerful electric forehead-lamp.

A large gouge should be employed to remove the superficial layers of cortex, and smaller ones as the bony excavation becomes deeper.

When the abscess cavity is sub-cortical and apical, as is so frequently the case in acute mastoid disease, it is unnecessary to extend the operation so as to open up the mastoid antrum, a layer of healthy bone often intervening between it and the apical collection of pus (Fig. 142). The antrum should, however, be opened up in all cases when this intervening layer of bone is softened and carious, or when granulation tissue is found spreading in the direction of its cavity.

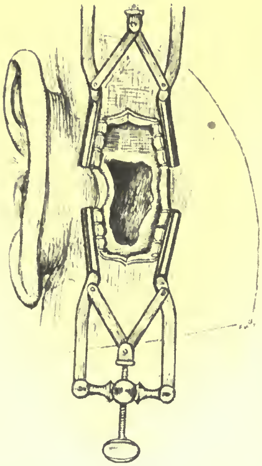

FIG. 142.—The mastoid operation as performed for the relief of a subcortical abscess. Soft parts kept retracted with Allport's self-retaining retractors.

Once the antrum has been opened, use should be made of an antrum hook (Fig. 144) or rectangular blunt-pointed silver probe to ascertain its size and depth and the condition of its walls. All overhanging bone should be removed with forceps, a sharp spoon, or an electrically-driven bur. In this way its cavity is thoroughly exposed, presenting finally the shape of a cone with smooth shelving walls whose truncated apex is formed by its inner wall. Search is now made for any fistulous tract leading backwards towards the sinus or upwards towards the middle fossa, any path of infection being followed by the removal of sufficient bone to ensure its complete exposure.

This necessitates at times ablation of the whole of the cancellous tissue of the process, leaving only the compact bone which forms its remaining walls.

The antrum should also be freely exposed in all those cases where there is reason to suspect the presence of intracranial or labyrinthine suppuration.

After Treatment.—The operation cavity having been thoroughly cleansed, is dried with pledgets of sterile wool and lightly packed with iodoform gauze. The superficial soft structures may now be brought together at the upper and lower ends of the wound, leaving sufficient space to enable the cavity to be inspected and packed, the object aimed at being to allow it to fill up gradually with healthy granulation tissue so that ultimately when healing is complete a firm mass of cicatricial tissue takes the place of what was formerly cancellous tissue. When dealing with small cavities, and especially when no communication with the antrum has had to be made, complete closure of the skin incision may at times be justified, otherwise it is better to conduct the after-treatment by means of packing or by the adoption of the blood-clot method of treatment.

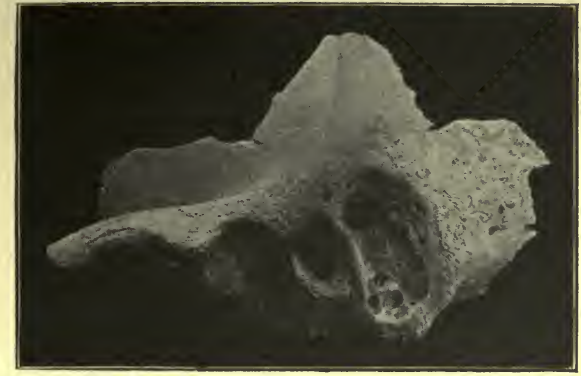

Fig. 143.—Cortex of mastoid process removed, showing mastoid cells and opening into antrum.

In acute abscess formation (subcortical) following acute otitis media it is unnecessary and inadvisable to open up the cavity of the middle ear, or in any way to disturb its contents, provided that the membrane has already been freely incised. The patient should be kept in bed for at least ten days after operation, the enforced rest permitting of the formation of healthy granulation tissue and materially assisting convalescence.

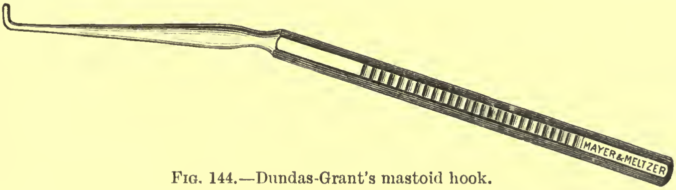

Fig. 144.—Dundas-Grant's mastoid hook.

It is, as a rule, unnecessary to change the packing more than once in every four or five days, as the less the granulations are disturbed the more rapid the healing of the bone wound.

Syringing should as far as possible be avoided, the cavity being mopped dry with pledgets of sterile gauze. Once the bony walls are seen to be completely covered with healthy granulations, the edges of the wound may be brought together, leaving only a small opening at the lower end of the incision through which a cigarette drain is passed to permit of the escape of serous fluid.

To enable the packing to be removed with as little pain and disturbance to the newly formed granulations as is possible, peroxide of hydrogen, which softens and detaches it, should be freely poured over the wound, after which it may be readily drawn out with forceps.

J. N. Roy[1] recommends carpeting the cavity with narrow strips of gauze soaked in sterile vaseline oil and packing with sterile pledgets of wool.

To facilitate convalescence the cavity in the bone may be allowed to fill up with blood-clot—which, should it remain aseptic, becomes organised and permits of the rapid healing of the wound—or with pure ox serum or Wright's hypertonic solution.

The blood-clot dressing, with or without temporary drainage, marks an advance in aural technique, and its employment is largely due to the teaching of Blake,[2] Blake-Reik,[3] Sohier Bryant,[4] and Sprague.[5]

To ensure success great care should be taken in the selection of suitable cases, and as clean an operative field as possible prepared. All laceration of tissue, especially of the periosteum, and contusions by ligatures and instruments should be carefully avoided. The walls of the bony cavity should also be carefully smoothed down, and the wound irrigated with sterilised normal salt solution at the body temperature or dried with sterile gauze.

Even although it may not be possible to ensure a perfectly aseptic wound, it has been shown that the blood possesses bactericidal properties more active when drawn from the vessels than when in circulation, but present only when it is alkaline. Hence, the use of antiseptics which reduces this alkalinity, should be avoided if the blood-clot method is to be adopted.

The most minute care should also be taken in disinfecting the skin and scalp prior to operation, and in the subsequent closure of the wound. The cavity in the bone is then allowed to fill with blood-clot, after which the original incision may be entirely sewn up, or a small cigarette drain inserted.

Reik advocates subcutaneous and continuous suture of the wound with silver wire, avoiding in this way the risk of using infected suture material and puncture of infected skin, as the *staphylococcus epidermidis albus* is found in its deeper layers. In addition, a material antagonistic to the growth of bacteria is employed. Although the number of cases likely to heal by primary union is small, the writer has had several where the blood-clot dressing, with the addition of temporary drainage, has proved successful, and has materially expedited convalescence. When drainage is to be employed a small cigarette drain, one-eighth of an inch in diameter, should be inserted into the cavity and brought out at the lowest point of the incision. It should be removed at the end of twenty-four or forty-eight hours. Its employment will not interfere with the healing of a non-infected wound, while should the clot become septic it permits of ready drainage of the infected area. It, in fact, acts as a compromise between packing the wound and employing the blood-clot method pure and simple, and is of use not only in simple mastoid operations but also in a certain number of cases where the complete post-aural operation has been performed. In successful cases convalescence is rapid, complete healing taking place in from five to seven days, with, as a rule, a most excellent cosmetic result.

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[1] *Montreal Med. Journal*, October 1907.

[2] *Am. Otolog. Society Trans.* vol. v. (1891-93), p. 32.

[3] *Surgical Pathology and Treatment of Diseases of the Ear*, 1906.

[4] *Am. Med. Assoc.*, 1906.

[5] *Am. Otolog. Society Trans.* vol. i. part i. (1905), p. 136.

A useful modification of the blood-clot method of treatment and primary suture is as follows :—The cavity formed by the removal of the mastoid cells is kept packed with gauze for four or five days. It is then repacked. Four or five days later the packing is again removed. The fresh and healthy granulations are now gently scraped with a sharp spoon, and the cavity allowed to fill with blood. The edges of the original skin incision, having been freshened, are then brought together and sutured. Provided that the cavity is aseptic, organisation of the blood-clot takes place and rapid healing ensues.

Should this method of treatment be contemplated it is advisable at the time of operation to reflect the periosteum both forwards and backwards as carefully as possible, and ultimately to bring its cut edges into as accurate apposition as circumstances permit.

Assistance may also at times be had from the subcutaneous injection of a vaccine made from the organisms of the discharge, being guided in the preparation of the vaccine by opsonic tests.

5. **Chronic Purulent Inflammation of the Mastoid Cells**—(*a*) **Indications for opening up the Mastoid Cells.**—The indications for opening up the accessory cavities of the middle ear in cases of chronic purulent otitis media depend upon certain subjective symptoms and objective indications.

As a rule both sets of symptoms are present and, taken together, make up a clinical picture justifying operative interference. At times, however, great difficulty is experienced in deciding whether an operation should be undertaken or not, more especially in those cases of long-continued suppurative middle-ear disease without complications. While certain surgeons advise operative interference in all cases of chronic septic otitis media of more than one year's duration, others hold strongly that unless absolute evidence of bone disease or of some other complication is present, local treatment with permeatal removal of polypi, granulation tissue, etc., should be persevered with indefinitely. Provided that in chronic cases the mastoid operation could be performed without risk, and with a definite certainty that it would arrest discharge, the arguments in favour of its immediate performance in all intractable cases would be very great. As, however, the operation cannot be performed without an element of risk, and as it necessitates a considerable period of rest and after-treatment, and as a certain degree of doubt exists as to whether it will definitely arrest discharge, both suppurative and non-suppurative, great care should be taken in the selection of cases for operation. The main objective symptoms indicating operation are the presence of constant foetid discharge, continuous or constantly recurring pain, at times local, at other times radiating over the affected side of the head, and evidences of cerebral irritation, such as vomiting, vertigo, "chocked" disc or optic neuritis, and impaired movements of the head.

Attacks of vertigo, transient or continuous, afford one of the most important indications for operation. They may be caused either by the pressure of the pent-up products of suppuration (*e.g.* cholesteatoma within the middle ear), by erosion of the bony capsule of the external or superior semicircular canal, or by actual invasion of the labyrinth by sepsis. Labyrinthine invasion is indicated by profound deafness upon the affected side, by absence of bone conduction, and by the lateralisation of the sound of a tuning-fork placed upon the vertex towards the sound ear.

Under such circumstances not only should the complete post-aural operation be performed at once, but, in addition, the outer labyrinthine wall should be carefully inspected, and the internal ear opened up if urgent symptoms supervene.

Symptoms of cerebral irritation, such as paresis or paralysis of various muscles or groups of muscles, convulsions, mental hebetude, unconsciousness, immobility of the pupil, nystagmus, etc., are indications for the immediate opening up of the accessory cavities of the middle ear, and for a careful search for any fistulous tract leading into the interior of the cranium or labyrinth.

The presence of symptoms of meningitis was formerly considered a contra-indication to operation, but is now regarded as an indication for the immediate removal of the focus of infection in the temporal bone.

The principal objective indications are :—

1. The presence of an intractable purulent and foetid discharge from the middle ear, uninfluenced by local and minor surgical treatment, and which on bacteriological examination is found to contain large numbers of *streptococci* or *meningococci*, and on cytological examination numerous lymphocytes, myelocytes, or acid-fast squames.

2. Polypi or granulations constantly recurring after removal, especially if of "attic" origin.

3. Deep-seated temporal bone caries.

4. A fistulous opening either through the mastoid cortex or posterior meatal wall leading down to carious foci or cholesteatomatous collections.

5. Cholesteatoma.

6. The occurrence of facial paralysis during the course of chronic suppurative otitis media.

7. Recurring attacks of acute mastoiditis grafted upon chronic infective disease.

8. Tuberculous disease of the middle ear or mastoid cells.

9. Stenosis, membranous or bony, of the external auditory meatus interfering with free escape of pus.

10. Obstinate antral suppuration, with perforation of the postero-superior quadrant of the membrane, especially if complicated with adhesion of the remaining portion of the membrana tympani to the inner wall of the middle ear.

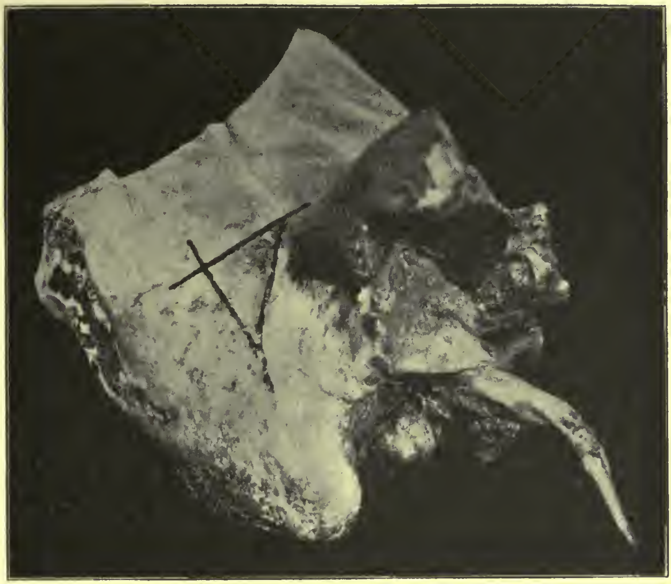

FIG. 145.—Temporal bone, showing the supra-meatal triangle and its relation to the external auditory meatus.

(*b*) **The Radical Mastoid Operation** (Küster-Bergmann, Schwartze-Stacke).—The preparation of the patient and field of operation for the complete post-aural or radical mastoid operation is conducted in the same manner as for the operation in cases of acute mastoiditis. The patient having been anaesthetised, a curved incision is made through the skin and subcutaneous tissues parallel to and $\frac{1}{4}$ inch behind the attachment of the auricle, the cutting edge of the knife being kept at right angles to the *planum mastoideum.* The incision should reach from the level of the upper attachment of the auricle to the mastoid apex. The soft tissues having slightly retracted, the incision is deepened through the periosteum and down to the bone throughout its whole length, care being taken to avoid incision of the temporal fascia, otherwise the temporal muscle is injured and troublesome haemorrhage results. To avoid injury to the muscle, the temporal fascia should be drawn out of the way with a rake or other form of retractor.

Haemorrhage from the cut vessels, which is at times profuse, should be arrested by the application of pressure-forceps or ligation of bleeding points. With a periosteal elevator the soft tissues are now raised from the surface of the *planum mastoideum* and drawn forward so as to completely expose its outer surface, the posterior margin of the bony meatus, and the supra-meatal or Henle's spine. The supra-meatal triangle is mapped out as follows:—"The base is formed by the posterior root of the zygoma running somewhat horizontally above; the portion of the descending plate of the squamous which forms the arch of the osseous part of the external auditory meatus below; and a base line uniting the two dropped from the former on a level with the posterior border of the external auditory meatus." This triangle (Fig. 145), forming as it does the outer wall of the antrum, is of the greatest importance as a superficial guide to its position, and although not always well defined may, as a rule, be mapped out with sufficient accuracy for practical purposes. Another method of defining the position of the antrum is to draw an imaginary horizontal line along the upper border of the bony meatus and another at right angles to the former and parallel to its posterior border. The triangle included within the intersection of these lines and the posterior curved border of the bony meatus corresponds with the outer antral wall.

During the raising of the soft tissues from the bone care should be taken to avoid injury to the periosteum. When it is adherent it should be dissected up with knife and forceps. In the event of a sub-periosteal abscess being present, it should be evacuated prior to making the preliminary incision, or opened up by the first incision. In any case its contents should be got rid of and its cavity cleansed before fully exposing the underlying bone. When a fistulous tract exists leading into the mastoid cells, the incision should, if possible, pass through it, and its edges be removed with scissors. In the event of the superimposed soft tissues being swollen and oedematous, it may be necessary, in order to secure sufficient room, to make another incision from the centre of the original curved incision, and at right angles to it horizontally backwards for a distance of $\frac{3}{4}$ of an inch or thereby. The wound is kept open by drawing the soft tissues, with the auricle attached, forwards with a broad rake retractor, or by means of the writer's self-retaining retractors, which have also the merit, by the pressure they exercise, of arresting oozing from the freshly cut surfaces. The postero-superior cartilaginous wall of the meatus is now separated from its attachment to the underlying bone by means of a narrow raspatory, and drawn forwards so as to lie in contact with the anterior wall of the cartilaginous meatus. It may be kept drawn forwards in this position with a retractor, or by means of a strip of sterile gauze or bandage passed in the form of a loop over the posterior cartilaginous wall and through the meatus. Care should be taken to avoid its laceration, as is easily done if undue traction be made, the more especially so if it happens to be softened as the result of previous inflammatory disease, otherwise the formation of suitable flaps will be seriously interfered with.

The anterior and inferior walls of the cartilaginous meatus should be left undisturbed, as it is from these surfaces that epithelial cells proceed to ultimately line the walls of the antro-tympanic cavity. The soft parts having now been pulled forwards, a view of the whole outer surface of the *planum mastoideum*, together with the deeper parts of the auditory meatus and the remains of the membrana tympani, is obtained.

Careful search with a probe should be made for any fistulous tract leading into the interior of the mastoid process, and, if found, enlarged by removal of bone so as to expose the underlying focus of disease. Also the depth from the surface of the mastoid antrum should be carefully ascertained by means of Stacke's probe. When the external surface of the bone appears normal, layer after layer is removed with a grooved chisel until the mastoid antrum is reached. Seeing that the antro-tympanic axis forms an acute angle with a line drawn through the centre of the head, the posterior parts of the antrum are invariably situated superficially to the cavity of the tympanum. In many cases, especially in pneumatic processes, the antrum is large and superficial, while as the result of disease its cavity may have become considerably expanded and, therefore, lie almost sub-cortically. On the other hand, as the result of progressive osteosclerosis or the persistence of the so-called *infantile type* (p. 165), the antrum may be extremely small and difficult to locate.

The antrum, having been laid open, should be carefully inspected, all overhanging bone being cut away and its walls rendered smooth by means of a bur. All infected mastoid cells should be opened up by a generous removal of the cortex and cleansed. It is advisable to note, however, that the bone wound should not be made larger than is absolutely necessary, as the larger it is the greater the time required for its repair. A Stacke's protector having been introduced into the *iter ad antrum*, the "bridge" of bone separating the antrum from the tympano-meatal cavity should be removed with bone forceps or chisel. In performing this part of the operation, care should be taken to avoid injury to the Fallopian aqueduct and the external semi-circular canal, which lie immediately under the "bridge" upon the outer labyrinthine wall. This may also be effected by retaining Stacke's probe in the *aditus* or by inserting a piece of sterilised sponge under the "bridge." In addition, it is necessary to remove the "bridge" with a gentle slope upwards and inwards, otherwise the facial nerve, as it descends downwards towards the stylo-mastoid foramen, is in danger of being wounded. The outer attic wall should now be removed by means of a fine chisel or attic forceps until the roof of the middle ear and the upper meatal wall form one continuous plane. The removal of the "bridge" and outer attic wall should be so complete that when a right-angled probe is introduced along the antro-tympanic roof it should be capable of being drawn out without meeting with any obstruction, while sufficient bone should be cut away along its lower wall to completely expose the facial spur.

To ensure success it is essential that the most minute care be taken to obtain a perfectly smooth condition of the bony walls of the enlarged antro-tympanic cavity. All overhanging bone should be smoothed down with a hand, or preferably with an electrically-driven bur, and all hollows obliterated so that no crevices are left for the accumulation of secretion. A short time spent over the preparation and sterilisation of the bony walls for the reception of the meatal flaps or for the implantation of epithelial grafts, frequently makes all the difference between a successful and a non-successful result (Fig. 146).

The antro-tympanic cavity having been freely opened up, it only remains to remove the remnants of the membrana tympani and diseased ossicles. The incus, if still present, is seized with a fine pair of forceps and lifted out, its attachment to the malleus and stapes readily giving way. The malleus may also be grasped with a pair of forceps and withdrawn. The region of the stapedio-vestibular articulation should be most carefully respected, the utmost care and gentleness being exercised if curetting be necessary—the movements of the curette being made from behind forwards as by so doing there is less risk of injury to the stapes than if they are made from before backwards.

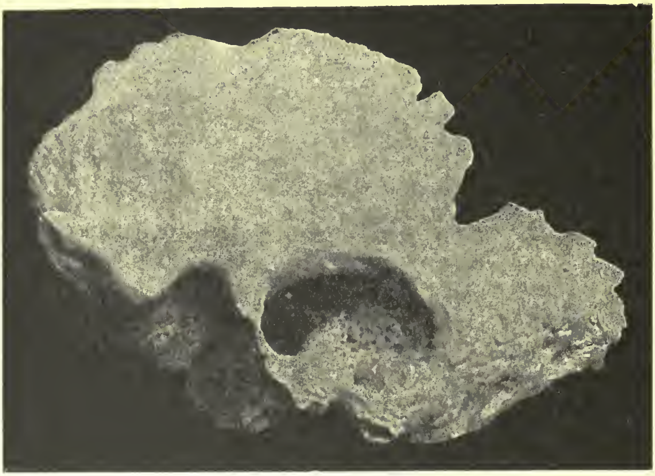

Fig. 146.—Temporal bone, showing the complete post-aural operation (Schwartze-Stacke).

Should the stapes be dislocated or unintentionally removed and a direct path into the labyrinth opened up, there is grave risk of suppurative labyrinthitis ensuing. Great care should also be taken in using the curette in the neighbourhood of the *fossula rotunda* and region of the aqueductus Fallopii, whose walls are often very thin and at times present dehiscences through which the facial nerve may be seen as a yellowish-red cord.

When curetting in the neighbourhood of the tympanic orifice of the Eustachian tube, which should be thoroughly done, the relation of the internal carotid artery to the antero-internal wall of the tympanum should be borne in mind, while in curetting the floor of the tympanum it must be remembered that it is occasionally very thin, at times perforated, and that in exceptional cases the bulb of the jugular vein actually projects into the tympanum. When the floor of the tympanum slopes much below the level of the floor of the external meatus it is advisable to remove a portion of the latter in order to prevent accumulation of secretion and subsequent formation of exuberant granulation tissue.

In the event of the anterior segment of the membrana tympani being intact, it should be carefully preserved and folded over the tympanic orifice of the Eustachian tube in order to secure its prompt closure and to assist in hastening the relining of the antro-tympanic cavity. Care should also be taken to avoid injury to the anterior and inferior walls of the auditory meatus, as it is from these walls that epithelium is in part furnished for subsequently covering the exenterated mastoid cells.

The object being to secure epidermisation of its bony walls, the packing may be left *in situ* for from five to six days, except in those cases where the bone lesion has been extensive and the discharge particularly foul. Under such circumstances it is advisable to change the dressings in the first instance, at any rate, every two or three days.

The original incision should be completely sewn up, horse-hair, silver wire, or ophthalmic cat-gut sutures being used for the purpose, except in those cases where it is desirable to retain a permanent retro-auricular fistula.

Accidents which may occur during the performance of the complete post-aural operation are injury to the facial nerve or external semicircular canal, luxation of the stapes, exposure of and injury to the sigmoid sinus or jugular bulb, and exposure of the dura mater.

The facial nerve (Fig. 147), from its relation to the "bridge" of bone separating the antral from the tympano-meatal cavity, is at times injured by injudicious use of the chisel. The employment of a Stacke's protector during this part of the operation serves as an efficient safeguard, and should always be made use of especially by those not fully conversant with operative technique. The fact also that dehiscences in the Fallopian aqueduct are by no means infrequent, and that the course of the nerve is not always constant, adds materially to the risks. The discovery of facial paralysis immediately after operation indicates direct injury to the nerve. Fortunately, however, the paralysis is generally only a temporary one, unless the damage is extensive. Should it occur from three to four days after the operation it is probably due to inflammation of its neurilemma, or to the presence of extravasated blood, and usually passes off within a few weeks.

Injury to the external semicircular canal, although not so frequent as injury to the facial nerve, is, nevertheless, a complication to be avoided, inducing as it does at times severe vertigo and nausea, while exposing the labyrinth to septic invasion. The canal, which appears as a yellowish-white prominence in the middle of the dark red inner antral wall, can as a rule be readily defined after removal of the "*bridge.*" Labyrinthine symptoms set up as the result of its injury generally disappear within a week or two.

Luxation of the stapes is a serious complication, ending generally in increased impairment of hearing, and permitting of direct septic invasion of the vestibule. As has already been mentioned, it is more likely to occur when curetting the tympanic mucosa from before backwards than from behind forwards. Although removal of the stapes, intentional or accidental, has at times been followed by an actual improvement in hearing power, it cannot but be regarded as an untoward accident when occurring during the performance of the complete post-aural operation for chronic sepsis of the middle-ear tract.

In rare instances during curettage of the *cavum hypo-tympanicum* the jugular bulb, which at times rises up into the cavity of the middle ear through a dehiscence in its floor, is injured with resulting profuse haemorrhage (Fig. 148).

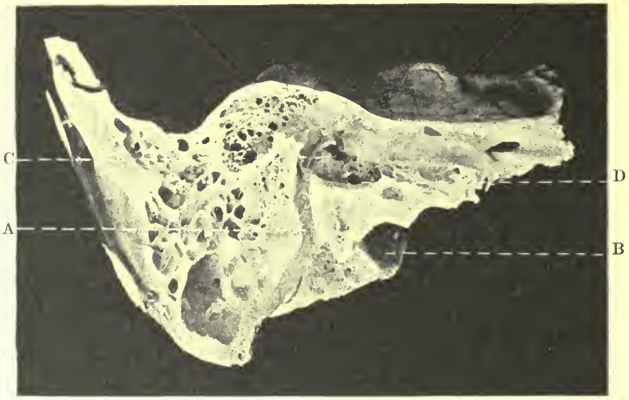

FIG. 147.—Diploetic mastoid process with large apical cell. A, Descending portion of Fallopian aqueduct; B, sinus jugularis; C, fenestra ovalis; D, fossula rotunda.

Injury to the lateral sinus, which is at times quite superficial and situated far forwards and close to the posterior meatal wall, is attended by profuse haemorrhage, and although seldom followed by untoward consequences, causes great inconvenience and necessitates plugging, with retention of the plug for five or six days.

Exposure of the dura mater during the performance of the complete post-aural operation is not, as a rule, a serious matter. If exposed, care should be taken to prevent chips of bone and purulent débris from getting locked up between it and the adjacent bone.

In order to cover as much of the denuded bone as possible, various flaps are fashioned from the posterior cartilaginous wall of the auditory meatus. Within a few days of the performance of the operation the smooth bony walls of the cavity become covered with a delicate layer of pale pink and healthy granulations which serve as a carpet upon which epithelium from the cut edges of the meatal flaps gradually creeps, so that in time the whole operation area becomes covered by a non-secreting but desquamating and dry cutaneous lining.

The particular method of cutting the flap or flaps depends to some extent upon the preference of the surgeon, the size and extent of the cavity in the bone, and whether the post-auricular incision is to be closed at the time of operation or not. In order to secure their accurate apposition to the underlying bone, all cartilage should be carefully dissected out.

The flaps in ordinary use are :—

1. *Körner's Rectangular Flap* (*Eiträge Erkrankungen der Schläfenbein*).—An incision is made along the line of junction of the posterior and superior walls of the cartilaginous meatus, beginning at its tympanic end and carried outwards well into the concha. A second incision, exactly parallel to the former, is carried outwards along the line of junction of the posterior and inferior meatal walls, also into the concha (Fig. 149). In this way a rectangular flap is secured, having its attachment at the concha. Haemorrhage is, as a rule, fairly severe, and requires at times ligation of bleeding points. A pliable layer of skin and subcutaneous tissue is now left which may be readily folded backwards so as to cover a portion of the denuded bone. To prevent "buckling" of the flap, and to ensure its remaining in accurate apposition with the underlying bone, a portion of the cartilage may be dissected off, or one or more sutures passed through it and the adjacent periosteum, after which the auricle should be replaced and the original post-auricular incision completely sewn up.

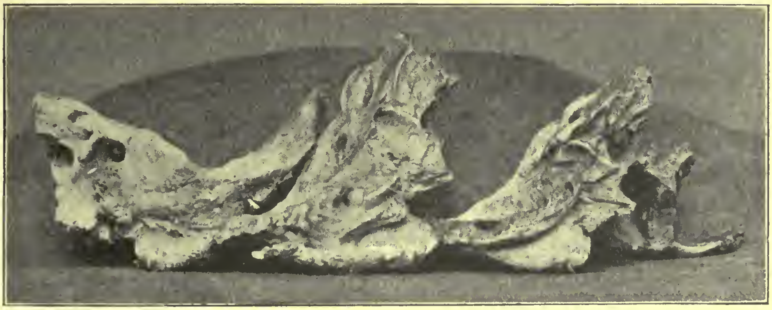

FIG. 148.—Three temporal bones illustrating variations in size of the jugular fossa.

A large tubular speculum is inserted into the now greatly enlarged meatus, and through it the antro-tympanic cavity is lightly packed with gauze.

If primary grafting of those portions of the antro-tympanic parietes not covered by the flap is to be performed, grafts may be placed *in situ* either before the post-auricular wound is closed or subsequently through the meatus.

It is desirable to avoid tight packing of the cavity as it causes unnecessary pain and is liable to end in sloughing of the flap. The disadvantages of the Körner flap are (1) the risk of subsequent perichondritis, and (2) the large and unsightly auditory meatus.

2. *Panse's Flap.*—An incision is made in the middle line of the posterior wall of the cartilaginous meatus through its entire thickness, commencing at its deeper or tympanic end and terminating in the concha. Another incision is now made at right angles to the former at its conchal end, extending upwards and downwards for a distance of about 6 mm., according to the extent of the wound in the bone (Fig. 150). In this way a T-shaped incision is constructed, enclosing two quadrilateral flaps which, after they have been denuded of their cartilage, are folded, the one upwards and the other downwards, over the bony walls of the cavity and anchored to adjacent periosteum by one or more silkworm gut sutures.

The post-auricular wound may now be entirely sewn up except in those cases where, during the performance of the radical operation, the lateral sinus or a considerable area of dura has been exposed. Under such circumstances it is held that a portion at least of the retro-auricular incision should be left unsutured, although the writer has in many such cases closed the external wound entirely without any untoward consequences. Through the enlarged auditory meatus packing is carefully and lightly introduced either with or without the aid of a speculum. The cosmetic disadvantages of the enlarged meatus are slight, and are rarely complained of, whilst its advantages are that through it all parts of the antro-tympanic cavity are readily visible and accessible, and after-treatment by packing easily accomplished.

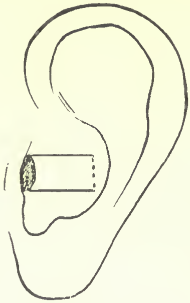

Fig. 149.—Körner's flap.
The dotted line shows where the flap is hinged backwards.

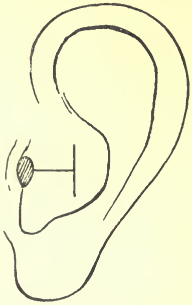

Fig. 150.—Panse's flap.

3. *Stacke's Flap.*—The radical operation having been completed and the antro-tympanic cavity sterilised, packing is introduced into all recesses, and into the *aditus*. The auricle is then grasped by the operator (the left auricle by the left hand and the right auricle by the right hand) and drawn slightly outwards and forwards. A sharp-pointed knife is then thrust through the cartilaginous meatus from behind, at the level of the junction of its posterior and superior walls, until it appears in the meatus. The edge of the knife is then turned so as to cut vertically

downwards, and an incision made exactly in the line where the meatus joins the auricle (Fig. 151). Should this vertical incision be made too far outwards it cuts into the cartilage of the concha, whereas if made too far inwards a small portion of the meatus will remain attached to the auricle, with the result that the opening into the operation cavity is too small. A retractor is now inserted into the slit in the posterior meatal wall and the auricle drawn forwards, while the posterior cartilaginous wall of the meatus is drawn backwards with a catch forceps. A pair of scissors is now inserted, one blade being in the meatus and the other in the operation cavity, and the cartilage divided along the line of junction of its superior and posterior walls, and as close to the former as possible. The flap thus formed—varying with the size of the cartilaginous meatus—is folded downwards and made to cover as much of the floor of the operation cavity as possible. Should it be unduly thick, as much cartilage may be removed as is required to allow it to lie in accurate apposition with the underlying bone, while any bleeding points—branches of the post-auricular artery—are ligated.

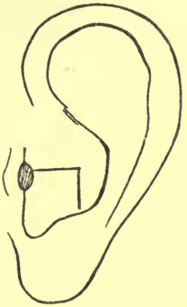

FIG. 151.—Stacke's flap.

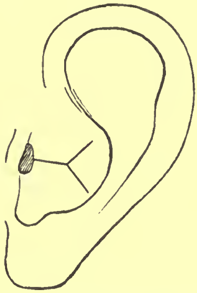

FIG. 152.—Siebenmann's flap.

The flap thus formed may be fixed down by one or two stitches to the lower angle of the wound, or held in position by forceps until the cavity has been repacked. After having removed the previous packing, and before repacking, the cavity should be carefully cleansed and dried. Fresh packing is then rapidly run in so as to fill the cavity and at the same time keep the flap in position. The auricle is then replaced and the edges of the original skin incision brought together by stitches or Michel's clips. Finally, the meatus is packed and its external orifice slightly distended with a plug of gauze.

4. *Siebenmann's Plastic Operation.*—An incision along the centre of the posterior wall of the cartilaginous meatus is made as far outwards as the concha. Two incisions are then made from the termination of the first incision, branching outwards into the concha so as to represent the letter Y. In this way three flaps are formed (Fig. 152). The upper and lower are fixed to the upper and lower bony walls of the meato-mastoid cavity and are retained in position either by sutures or packing.

The triangular flap is first denuded of its cartilage by careful dissection and is then folded backwards against the posterior surface of the bony wound, being retained in position by packing introduced through the now enlarged meatus.

On account of the somewhat unsightly size of the orifice of the meatus Neumann cuts the arms of the Y-shaped flaps comparatively short—that is, not so far into the concha—and does not dissect off the underlying cartilage.

5. *Milligan's Plastic Operation.*—A long knife is introduced at the junction of the superior with the posterior wall of the cartilaginous meatus and an incision made outwards, well into the concha. The knife is then made to sweep downwards, following the curve of the concha as far as the inferior wall of the meatus. A large flap is thus made consisting of the whole of the posterior and a portion of the inferior cartilaginous wall of the meatus (Fig. 153). This flap is then folded down on to the floor of the meato-mastoid cavity and fixed by two or more sutures passed through the skin and the flap, and tied over a rubber drainage tube or sterilised lead plate. The auricle is then replaced and the original skin incision entirely sewn up, except at its lowest point through which a strip of gauze is passed. The object of this is to relieve tension and so to prevent the sloughing of the tissue between the mattress sutures, which is very prone to occur on account of the tightness with which they have to be tied in order to keep the flap accurately in position. The result is a considerably enlarged orifice of the external meatus, through which inspection of the whole antro-tympanic cavity is particularly easy, and through which packing is readily introduced.

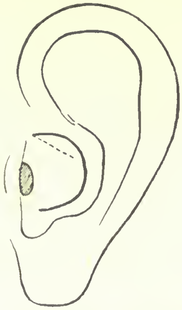

Fig. 153.—Milligan's flap.
The dotted line shows the incision along the postero-superior meatal wall; the dark line, the incision through the concha.

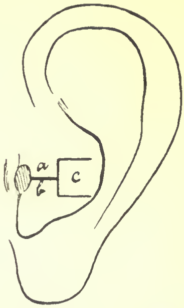

Fig. 154.—Brühl's flap.

6. *Brühl's Plastic Operation.*—This is a combination of Panse's and Körner's flaps. An incision is made outwards along the middle line of the posterior wall of the cartilaginous meatus and for about two-thirds of its whole length. Two short incisions are then made, the one upwards, the other downwards at right angles to the first incision, and are then carried outwards at a right angle well into the concha, the whole representing a miniature two-bladed fork (Fig. 154 *a*, *b*, *c*). The flap *a* is then

turned upwards and the flap *b* downwards, while the flap *c*, previously denuded of its cartilage, is turned backwards against the posterior wall of the meato-mastoid cavity, where it is kept in position by packing introduced through the meatus.

After Treatment.—For the first week the patient should be kept in bed and encouraged to lie upon the affected side. To obviate pressure pain a pillow with a large circular opening, into which the affected ear fits, may be made use of (Mackenzie).

Light nutritious diet should be given, and the bowels kept open by means of an occasional aperient.

Provided that there is no pyrexia, severe pain, or soaking of the bandages, it is advisable to leave the dressing *in situ* for five or six days, as by so doing the flaps have time to become adherent to the underlying bone, and the walls of the antro-tympanic cavity to cover with healthy granulation tissue.

The first dressing should invariably be performed with the patient lying down, for fear of faintness or giddiness supervening. In young children it is advisable to administer a general anaesthetic. The removal of the gauze packing may be facilitated by soaking with peroxide of hydrogen solution. After all packing has been removed, the walls of the cavity should be carefully inspected and, if necessary, cleansed with some warm antiseptic solution. At this stage it will in favourable cases be found that the cavity is covered, with the exception of the bony external semicircular canal and the Fallopian aqueduct, with a layer of pale red and vascular granulations.

Provided that no tendency to the formation of exuberant granulation tissue is noticed the cavity should again be packed with a strip of iodoform gauze, care being taken to carry the gauze well into all recesses and into the *aditus*.

This packing should be allowed to remain *in situ* from three to five days, after which subsequent dressings should be made every two or three days.

When a tendency to the formation of exuberant granulation tissue is noted the healing chamber should be packed with 3 per cent isoform gauze, which from its mild caustic action successfully retards its growth. In addition, packing with isoform gauze has the effect of diminishing the amount of discharge. This packing should be changed every second day as the isoform is used up rapidly, and, if not renewed, a disagreeable odour results.

When, however, exuberant granulations have formed, packing the cavity with 10 per cent isoform gauze, or the local application of lactic acid (20 to 30 per cent solution, Grunert), or zinc permanganate (gr. $\frac{1}{8}$ to 1 oz.) is advisable.

(*c*) **Stacke's Operation.**[1]—An incision is made parallel to and a quarter of an inch behind the attachment of the auricle, and extending around it from the tip of the mastoid process to the temporal region. The various layers of soft tissue from the apex to the base of the process are cut through down to the bone, but above the level of the mastoid base care should be taken to avoid injury to the temporal fascia, otherwise troublesome oozing of blood from the temporal muscle takes place. With a raspatory the soft tissues are pushed forwards so as to fully expose the postero-superior margin of the bony meatus and posterior root of the zygomatic process. The cartilaginous meatus is next separated from its attachments to the posterior and superior meatal walls and cut through as near to the membrana tympani as possible.

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[1] *Die operative Freilegung der Mittelohrsräume* (Tübingen, 1897).

The auricle with the now detached cartilaginous meatus is drawn forwards with a retractor or suitably disposed loop of bandage so as to fully expose the membrana tympani. All remnants of the membrane together with the malleus, if still present, are removed. The outer attic wall is then carefully cut away with a small and highly-tempered chisel until the roof of the middle ear and the superior wall of the auditory meatus form one continuous plane.

In order to avoid injury to the Fallopian aqueduct and external semicircular canal, Stacke's protector (Fig. 155) is gently insinuated along the "iter," towards the antrum, and all bone forming the postero-superior wall of the meatus chiselled away until it enters the antrum quite freely.

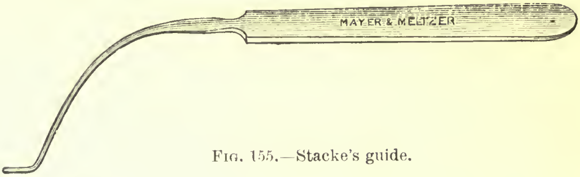

FIG. 155.—Stacke's guide.

The incus is now looked for, and, if present, extracted with forceps. Finally, all bone external to the cavity of the antrum is removed until antrum, tympanum, and external auditory meatus form one continuous cavity. It is important that as much of the posterior meatal wall be removed as will admit of the inferior wall of the auditory meatus passing directly into the floor of the antrum.

All diseased soft tissue, carious bone, and cholesteatomatous débris is then thoroughly scraped out with a curette, the walls of the cavity smoothed by hand or electrically driven burs, and finally flaps cut from the cartilaginous meatus so as to line as much of the bared bony walls of the antro-meatal cavity as possible.

Stacke's operation should be performed in preference to the complete radical or post-aural operation in those cases where the diseased process is limited to the regions of the attic and antrum, and where, as the result of a progressive osteo-sclerosis of the mastoid process, the natural size of the antrum is diminished and its relation to other parts somewhat altered. It is also to be selected in those cases where the lateral sinus is situated far forwards and close to the posterior wall of the meatus, and when, consequently, it is impossible to reach the antrum by the ordinary or more direct route through the mastoid cortex.

In addition, the fact that a forwardly-situated sinus is frequently associated with a low-lying middle fossa necessitates approaching the antrum by way of the postero-superior meatal wall.

(*d*) **Wolf's Operation.**—The preliminary steps of the operation are similar to those described in the Küster-Bergmann procedure, the special point being that the antrum is opened and the postero-superior meatal wall removed at one and the same time. To effect this the gouge is placed immediately behind the postero-superior margin of the auditory meatus, and layer after layer of bone cut away, each application of the gouge being a little more posterior and inferior to the one immediately preceding it. In this way a deep gutter is cut in the bone, which rapidly exposes the antrum and aditus ad antrum. Once the antrum has been exposed, the subsequent steps in the operation are as in the Küster-Bergmann procedure.

(*e*) **Ballance's Operation.**—An incision is made, commencing above and half an inch in front of the meatus, in the line of the hair. It is carried first backwards and then downwards, still following the line of the hair until that line passes on to the neck. It is then continued downwards and forwards to the posterior part of the mastoid apex. The skin is now raised for one-third of an inch towards the pinna. A second incision, parallel to the former, is then made down to the bone, and all superficial structures raised by means of an elevator as far forward as the posterior edge of the bony meatus, exposing the linea temporalis and the suprameatal spine of Henle. The auricle and the soft structures included in the flap are now drawn forwards by means of a broad rake or self-retaining retractor. A complete post-aural operation is then performed, special attention being paid to making the superficial opening in the bone as large and as roomy as possible and to carefully and thoroughly clearing the fossa of the aqueduct (recessus tympanicus sub-aqueductu Fallopii) of all infective granulation tissue.

The bony walls of the antro-tympanic cavity should now be scrutinised, all elevations and depressions being burred away so as to produce smooth and highly-polished surfaces.

A flap is cut from the posterior cartilaginous wall of the meatus as follows:—With a long and narrow knife the inferior wall of the meatus is cut through vertically, the incision being carried outwards, well into the concha. The incision in the concha is carried with a curve running upwards and backwards until it reaches the level of the anterior commencement of the helix. The flap thus formed, which includes the whole of the posterior wall of the cartilaginous meatus, is then pushed upwards and backwards and attached by silkworm-gut threads to the mastoid flap, raw surface to raw surface (Fig. 156). Before actually passing the supporting stitches all redundant tissue, including the cartilage, is cut away, so as to facilitate the accurate apposition of the meatal flap to the skin flap, the ragged edges of the former being trimmed with scissors.

If the ultimate object be grafting of the cavity, the tympanic orifice of the Eustachian tube should be curetted or cauterised so as to secure its obliteration. In the absence of tympanic contents the Eustachian tube subserves no physiological function, while if allowed to remain patent it may act as a means of conveying infection from the naso-pharynx and of thus indefinitely prolonging suppuration.

The writer is in the habit of using a small, conical-shaped bur with which to remove the mucosa lining the tympanic orifice of the tube, a method which he has found leads, as a rule, to the development of a firm cicatrix.

The bone cavity is now thoroughly cleansed with an efficient antiseptic lotion, dried and lightly packed with sterile gauze, whose end is brought out through the enlarged meatus. The external incision is then entirely closed with horse-hair sutures. All external dressings are changed every day or every second day, but the gauze packing may, as a rule, be left for several days except in those cases where the wound in the bone has been particularly foul and septic.

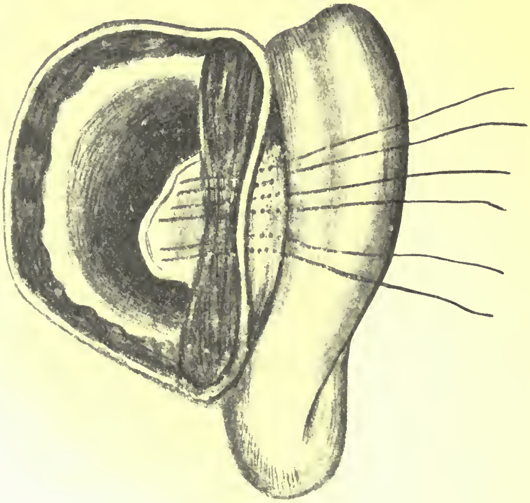

FIG. 156.—Ballance's concho-meatal flap.

Skin Grafting.—Under favourable circumstances the epithelial grafting operation may be performed in children at the end of a week and in adults at the end of ten or fourteen days. The day before the grafting operation is undertaken all packing is removed and the cavity well irrigated with a warm solution of 1 in 80 carbolic acid. At the same time the area from which the graft is to be cut is thoroughly washed with soft soap and water, shaved if necessary, and covered with an antiseptic gauze dressing which is allowed to remain in position till the operator is ready to cut the graft. On the morning of the operation the cavity is thoroughly washed out with warm sterile normal salt solution.

The original post-aural incision is then reopened throughout its entire length, and the pinna drawn forwards as in the first operation. To arrest oozing from the edges of the incision and from the granulating surfaces irrigation with hot sterile isotonic, or 1 per cent calcium chloride and salt solution may be employed, or the raw surfaces covered with pieces of lint, ½ inch square, soaked in sterilised adrenalin (1 to 1000). In this way the walls of the antro-tympanic cavity are thoroughly dried before the application of the graft which otherwise could not be made to lie in accurate apposition with the delicate layer of pink granulation tissue covering its bony walls.

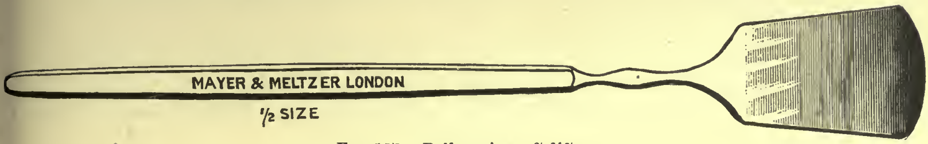

Fig. 157.—Ballance's graft lifter.

A large epithelial graft, as thin as possible, is now cut from the previously prepared thigh or arm, preferably the former, and from a region with as few hair follicles as possible. In order to secure a successful graft the skin should be forcibly stretched, and kept stretched during the time it is shaved off. To effect efficient stretching a wooden roller may be placed across the upper part of the thigh and kept well pressed into the soft tissues by an assistant, whilst the operator holds the lower part of the thigh in his left hand and makes forcible downward traction. To facilitate the cutting of the graft the area of skin from which it is to be obtained should be well moistened with a glycerine alcoholic solution of salt (normal saline solution ℥ vii., glycerine ʒ ij., and alcohol ℥ i.), the aim of the surgeon being to cut a graft large enough to cover the whole of the surface it is desired to epidermise. The graft having once been cut is first floated from the razor on to warm normal salt solution and then spread out on a specially designed lifter (Fig. 157). The anterior extremity of the lifter with the graft lying upon it is placed against the outer or

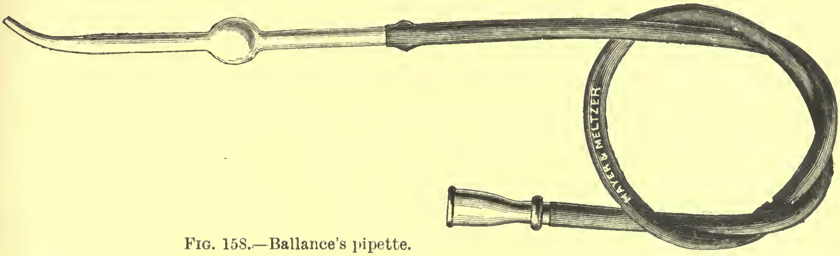

Fig. 158.—Ballance's pipette.

superficial edge of the anterior wall of the cavity in the bone produced by the first operation, while the end of the graft is coaxed on to this superficial edge and also on to the adjoining superficial edge of the roof of the cavity just below the linea temporalis, and held in position by the point of a long silver probe. The lifter is then carefully withdrawn leaving the graft overhanging the wound in the bone. With a little manipulation, aided by suction with a pipette (Fig. 158), it may be made to sink into the antro-tympanic cavity, to cover and to lie flat against the following parts:—

1. The anterior wall of the cavity.
2. The anterior part of the roof of the cavity formed by the tegmen tympani, and the superior wall of the enlarged osseous meatus.
3. The inner walls of the attic and tympanum.
4. The tegmen antri.
5. The ridge formed by the Fallopian aqueduct.
6. The inner wall of the antrum.

The graft should be gently but firmly pressed home against the walls of the cavity by means of stoppers (Fig. 159), all air, fluid, or thin blood clot intervening between it and the layer of granulations covering the bone being carefully sucked out with a pipette. Instead of using a stopper to press the graft home, small pledgets of gauze on angular forceps may be employed. In the event of one graft not being sufficient to line the whole of the cavity, a second or even a third may be made use of, care being taken to avoid overlapping or intervals between the grafts. When the grafting is complete the definition of all eminences and depressions should be as clear to the eye as before the operation, the only difference being a greater smoothness due to the epithelial covering (Fig. 160).

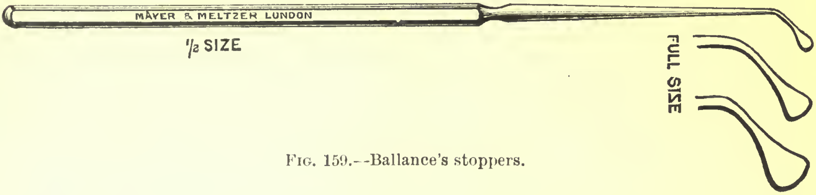

Fig. 159.—Ballance's stoppers.

Instead of insinuating the graft into the operation cavity by means of suction and stoppering, Milligan recommends filling the cavity with normal salt solution, floating the graft upon the fluid, and then sucking out the fluid per meatum with a large pipette. As the fluid is withdrawn the graft sinks into the cavity, and ultimately comes to lie in accurate apposition with its granulating walls.

Another method is to use, instead of the lifter, a piece of sterilised crape-tissue upon which the graft with its cut surface facing upwards is carefully spread. The crape is then gathered up, and with the graft still clinging to it is inserted into the operation cavity by way of the auditory meatus, and with the aid of a probe spread over its walls.

To avoid injury to the graft and to prevent its being pulled out during the withdrawal of subsequent dressings, Ballance recommends the employment of pure gold-leaf $\frac{1}{16000}$ to $\frac{1}{200000}$ of an inch in thickness. A piece of leaf about 2 inches square is carefully laid over the opening in the bone. It is then very gently pushed home by a steel stopper until the irregularities of the bone cavity are again perfectly clear.

A narrow strip of dry iodoform gauze is now packed into the cavity and brought out through the meatus, after which the mastoid flap is again completely closed and external dressings applied. Instead of using gold-leaf as a protective agent, small pellets of sterile wool about the size of a pea enclosed in gauze and powdered with aristol or xeroform may be employed. A pellet is taken upon an angular forceps, and gently pressed against that portion of the graft covering the antero-inferior corner of the bone wound. Other pellets are then fitted in, one upon the top of the other, until the whole cavity is full, and the graft firmly in position. A strip of dry gauze is finally inserted and brought out through the meatus as already described. In the course of a week the plug or series of pellets is removed. If gold-leaf has been used it may be left a few days longer and ultimately removed with a pair of forceps. A strip of dry gauze is again inserted against the now white and desquamating graft to soak up any discharge which may be oozing from the cut edges of the conchal and inner surfaces of the mastoid flap. To obviate this discharge and to promote rapid healing it is at times worth while to graft these cut surfaces.

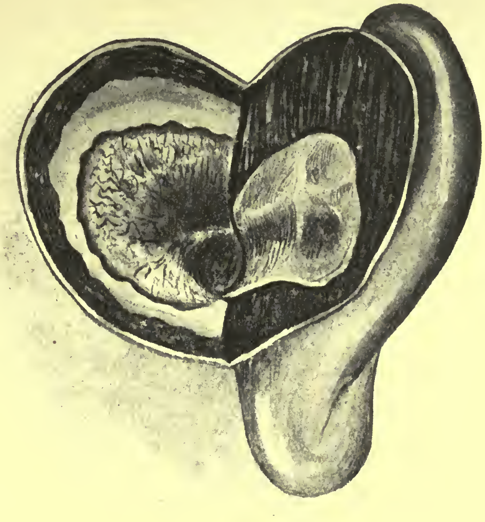

FIG. 160.—Epithelial graft in position. Walls of antro-tympanic cavity sharply and accurately defined.

In the event of the bone wound being unusually large it is unnecessary to graft its posterior parts.

Before cutting the graft Waggett[1] suggests varnishing the proposed area of the limb from which it is to be cut with "newskin." After removal of the antiseptic dressing a few drops of "newskin" are poured over the thigh, and quickly spread out with the finger or a brush. In one minute the newskin has dried and formed a firm varnish. When the skin is stretched, as previously described, no difficulty is experienced in cutting a uniform graft of large dimensions. The advantage claimed is that by the use of the varnish the graft is prevented from curling, while no trouble is found in manipulating it and even in fixing it to the edges of the meatal flaps with stitches. Wyatt Wingrave recommends a solution of celloidin in acetone (10 per cent).

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[1] *Journal of Laryngol. and Otolog.* July 1905, p. 363.

A method advocated by Deanesly is to apply sticking-plaster to the thigh before cutting the graft.

Grafting the antro-tympanic cavity as above described has many advantages, not the least being the subsequent rapid convalescence and freedom from a long series of irksome and painful dressings. Objections raised against grafting are that a second operation is required, that the graft is prone to shut in the products of suppuration, and that it increases the existing degree of deafness. With regard to a second operation, the objection against it is purely academic, provided that the patient has previously been instructed as to the necessity of its performance. In addition, no graft will, under any circumstances, be found to adhere should suppuration take place beneath it, while those cases in which the lateral sinus or large areas of dura have been exposed at the time of the primary operation are, as the outcome of practical experience, deemed unsuitable for grafting. That it increases the existing degree of deafness is not the writer's experience after the performance of a large number of grafting operations and after many years' observation. In 100 cases in which the complete post-aural operation, followed by grafting, was performed, and in which careful notes of the hearing power were made prior to operation, and months, and, in some cases, years afterwards, and in which complete epithelialisation had taken place, the hearing power in 64 per cent was materially improved, in 24 per cent it remained practically what it was before operation, while in 12 per cent it was made worse. Moreover, in those cases of severe and extensive disease in which the complete post-aural operation is called for, the hearing power before operation is, as a rule, so impaired that it may be disregarded, whilst it should be recollected that the *raison d'être* of the operation is not specially to preserve the hearing power but to get rid of the many risks attending the presence of temporal-bone suppuration and to save life. Furthermore, in those cases of middle-ear suppuration, where the hearing power is good prior to operation, some procedure, *e.g.* Küster's or Stacke's operation, *i.e.* one which falls short of a complete post-aural operation, is not only called for, but is, as a rule, sufficient.

Primary grafting of the bone wound has been suggested, and has been practised by a few surgeons. If at the time of the radical operation all diseased foci have been cleared out and the cavity rendered sterile, the chances are in favour of the graft adhering to the freshly prepared and smooth bone. Should it hold, convalescence is naturally much more rapid; while should it fail to adhere, no injury has been inflicted.

Intra-auricular Transplantation of Skin Grafts.—Politzer[1] has suggested an intra-auricular method of grafting the bony walls of the meato-mastoid cavity in those cases where primary suture of the skin wound has been effected.

In from five to six days after the operation, by which time the exposed bony surfaces are covered with a delicate layer of pink granulation tissue, the packing is removed and the operation cavity carefully cleansed with perhydrol solution and then with sterilised water. A graft is now cut from the inner surface of the leg or arm and spread out upon a flat knife or "lifter." It is then floated on the bulb of a specially constructed cannula to which a small air-bag is attached. Under illumination the cannula, with graft attached, is passed into the meatus, and up against the bony walls of the cavity. By gently compressing the air-bag the graft is blown upon its granulating walls. The cannula is then carefully removed and any portions of the graft which have become curled up and are not lying in accurate position with the granulating surfaces are folded back with a blunt-pointed probe or forceps. As many grafts as are necessary to completely cover the raw surfaces are placed in position one by one.

Small pledgets of sterile wool, wrapped in gauze and covered with xeroform powder, are now placed against the various grafts so as to keep them accurately in position. Adherence of the grafts to the underlying granulation tissue takes place in favourable cases within a few days, provided that there is no suppuration. J. S. Barr, of Glasgow, has suggested an almost similar plan, using a piece of hollow bent glass tube to which an air-bag is attached. The graft is placed across the open end of the tube and when *in situ* is blown on to the granulating surface of the meato-mastoid cavity.

6. **Latent Mastoiditis.**—This particular form of mastoid infection is undoubtedly rare, but that it occurs is confirmed by the writer's observation of two cases, both of streptococcal origin, and by the records of isolated reports.

According to Politzer[2] "the characteristic feature of this form of disease is the absence of reactive inflammatory symptoms in the tympanic cavity. The intact membrane is cloudy and lustreless, the blood-vessels of the handle of the malleus are injected and the osseous canal is slightly reddened. The hearing power is just as in middle-ear catarrh slightly impaired."

In both of the cases observed by the writer the hearing power and the appearances presented by the membrana tympani were normal. In both, the temperature was raised, 99·4° F. and 100° F., and there was tenderness not amounting to actual pain over the mastoid cortex. In neither case was the auricle displaced, and no sagging of the postero-superior wall of the meatus was noted.

In both cases the mastoid cells were found broken down and filled with a mucopurulent secretion and pale oedematous granulations.

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[1] *Wiener med. Wochenschrift*, 1904.

[2] *Diseases of the Ear*, 5th ed. p. 560.

Bacteriological examination revealed the presence of streptococci in almost pure cultivation.

In such cases the organism no doubt obtains entrance to the cellular spaces of the mastoid process by way of the middle-ear cleft and for some unexplained reason lies dormant, just as the tubercle bacillus may do, until roused to activity by some intercurrent inflammatory process.

Cases of latent mastoiditis, although unquestionably rare, are probably of more frequent occurrence than is usually supposed, and may serve to explain the aetiology of certain otherwise inexplicable intracranial or systemic infections.

7. **Bezold's Mastoiditis.**—This particular form of infection of the mastoid cells is characterised by the formation of an apical abscess followed by perforation of the mesial wall of the mastoid process, and by the collection of pus under the deep cervical fascia. The presence of large, thin-walled apical cells in a pneumatic process, and of a cortex of sufficient thickness to offer resistance to the exit of pent-up purulent exudation favours its formation (Fig. 161). It is more common in adults than in children. After perforation has taken place tracts of infection spread, guided by the large vessels or muscles of the neck downwards towards the clavicle, inwards towards the pharynx, or backwards under the base of the skull. In exceptional cases pus may reach the mediastinum.

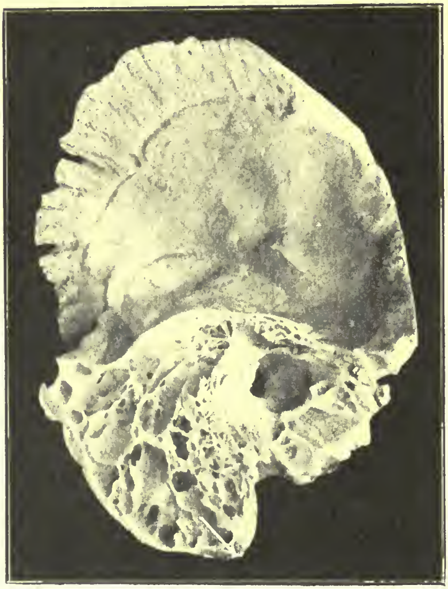

FIG. 161.—Squamo-mastoid portion of temporal bone viewed from within, showing pneumatic cells of mastoid process and the mastoid antrum. The arrow indicates the usual situation of perforation of inner table.

Symptoms.—The subjective symptoms are pain in the region of the mastoid apex, high temperature, and in cases where pus reaches the lateral wall of the pharynx or larynx dysphagia, with at times dyspnoea, in addition to the symptoms common to acute or chronic suppurative otitis media.

The objective indications are the presence of a hard, tender, brawny, and oedematous swelling in the neck, which gradually becomes softer as pus accumulates or works its way to the surface, and a varying amount of torticollis.

Owing to the depth at which pus is situated fluctuation may for a time be difficult to demonstrate.

The disease is apt to run a protracted course on account of the difficulty of securing efficient drainage.

Diagnosis.—The presence of a hard, tender, oval-shaped swelling below the apex of the mastoid process, extending downwards into the tissues of the neck in a case of acute, chronic, latent, or tuberculous disease of the mastoid cells, while the superimposed soft tissues over the process itself show little or no evidence of infiltration, is diagnostic of perforation of the median mastoid wall and of extension of suppuration under the deep cervical fascia. Although it is almost invariable to have preceding perforative otitis media cases of Bezold's mastoiditis occasionally occur without rupture of the membrane.[1] Care should be taken to differentiate Bezold's mastoiditis from inflammation of the deep cervical glands, and from phlebitis of the jugular vein.

Treatment.—Treatment is entirely surgical and should be undertaken at the earliest possible moment. Thorough exposure of the apical cells, followed by ablation of the mastoid apex, is called for. All softened and carious bone and all infective granulation tissue should be scraped out with a sharp spoon, and the tract of infection in the neck opened up.

This may be accomplished by passing a long and blunt probe downwards into the neck, following the course pus has already taken, and then making it project outwardly, usually in front of the anterior border of the sterno-mastoid muscle, and finally cutting down upon it from the surface.

The abscess cavity is now thoroughly washed out, and a drainage tube or gauze drain inserted and made to project at both ends of the wound; or the whole length of the abscess cavity may be laid open by a long incision and subsequently allowed to granulate from the bottom.

8. **Diabetic Mastoiditis.**—Suppurative inflammation of the cancellous spaces of the mastoid process occurring in diabetic subjects is characterised by insidious but often rapid destruction of bone, with or without pain. The membrana tympani is in such cases found to be acutely congested and bulging, and the lumen of the meatus stenosed from prolapse of its postero-superior wall. At the commencement there is comparatively little systemic disturbance as indicated by a normal or even subnormal temperature, but later the temperature may rise, accompanied by mastoid pain, oedema, and by headache. The absence of any marked inflammatory reaction, and the pale, flabby, and oedematous character of the granulations found on opening up the process, are indicative of low vitality rather than of mild infection. Later on, great destruction of bone takes place, accompanied by the formation of sequestra, exposure of the dura or sigmoid sinus, and by a profuse, blood-stained, and purulent discharge.

Course and Terminations.—The course of disease is, as a rule, rapid, death being due either to diabetic coma or to the effects of pyogenic infection in an already debilitated subject.

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[1] Knapp, *Archives of Otolog.* vol. xxiii. No. 1.

Prognosis.—The prognosis is always grave, and is rendered the more serious the higher the percentage of sugar present in the urine, while if acetone or diacetic acid are also found the outlook is very grave. The younger the patient the greater the danger of post-operative diabetic coma, while the presence of arterio-sclerosis or diabetic tabes, as evidenced by loss of the patellar reflex, adds materially to the gravity of the case. The earlier that operative interference is undertaken the better the outlook.

Treatment.—The great danger of any operative interference in diabetic mastoiditis is the risk of death from coma following the administration of an anaesthetic. On the other hand, the earlier operative interference is undertaken, and the more rapidly it is carried out, the greater the chances of a successful result. Prior to operation, a most rigid anti-diabetic diet should be prescribed, and large doses of bicarbonate of soda or codeine ordered. In addition, a most careful urinary analysis should be undertaken, the total amount passed in twenty-four hours being ascertained, and the percentage of sugar estimated from a twenty-four hours' specimen. The presence of acetone prohibits operation. Following the administration of either chloroform or ether there may be an increase, a decrease, or a temporary disappearance of sugar in the urine. The supervention of dyspnoea, especially if after ether narcosis, is almost invariably fatal. Injection of strychnine, removal of the mastoid cortex, and thorough curettement of the infected mastoid cells should be undertaken at as early a stage as is possible, and performed with the greatest possible rapidity. When the disease extends to the inner mastoid table or to its roof it should be completely removed, so that the floor of the operation cavity is formed by dura mater from which healthy granulations subsequently spring. In addition, the bulging of the dura into the wound lessens its depth, while transmitted pulsations assist in maintaining efficient drainage. The cavity in the bone, after having been cleansed, is lightly packed and left open throughout its entire length.

Considering the great risks of general anaesthesia in these cases, the question arises as to whether operative interference could not be undertaken under nitrous oxide and oxygen, or after the subcutaneous injection of cocaine and adrenalin (p. 56).

In four cases of diabetic mastoid disease coming under the writer's care, with respectively 2½, 3, 5, and 7 per cent of sugar present, operation was undertaken with a successful result in three cases, the fourth dying from diabetic coma associated with a gangrenous condition of the operation wound. A successful result depends to a large extent upon rapidity of operation and provision of free drainage. The wound should be left entirely open.

Plastic Operations for the Closure of a Persistent Retro-auricular Fistula.—The maintenance of a persistent retro-auricular fistula is seldom necessary. Cases occur, however, when, owing to the fact that a large amount of bone has had to be removed, or when the post-auricular wound has had to be kept open for the drainage of a brain or perisinusal abscess, complete healing may not take place.

In such cases, some form of plastic operation has to be performed to secure closure of what otherwise is an unsightly deformity.

When the opening is small its closure may be effected after thorough sterilisation by paring its epithelial edges, undermining freely, and inserting a few horsehair stitches. To avoid the possibility of any tension it is at times advisable to make a crescentic incision through the skin parallel to the auricle, and about half an inch behind the fistula. Should the surgeon be called upon to close a large opening, various plans of procedure may be adopted.

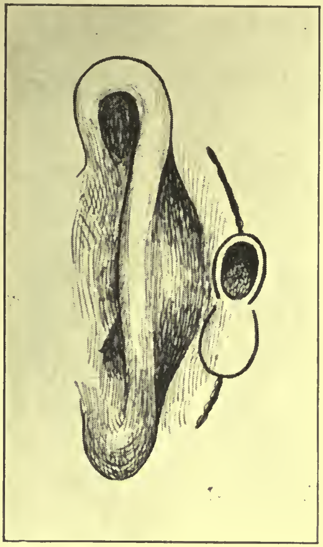

FIG. 162.—Mosetig-Moorhof operation. Formation of flap slightly larger than the fistula to be closed.

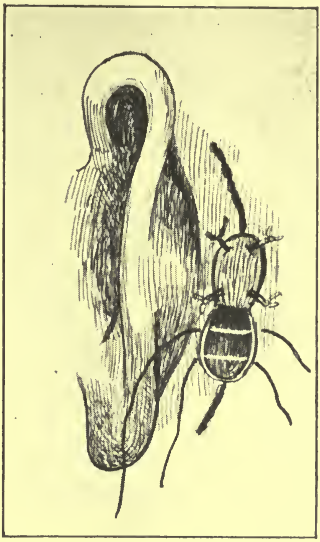

FIG. 163.—Mosetig-Moorhof operation. Flap turned upwards and sutured to the already pared edges of the retro-auricular fistula.

1. *The Mosetig-Moorhof Operation.*[1]—A crescentic incision is made below the fistula so as to include a flap slightly larger than the opening to be closed. The first incision is made through skin only. A second crescentic incision, following the former exactly and a little distance from it, is made also in the first instance through skin only (Fig. 162). The narrow strip of epithelium between the two incisions is now dissected up and removed. The second incision is then deepened to the underlying fascia, and the flap, which has its base at the lower border of the fistula, dissected upwards (Fig. 163).

The epithelial margins of the retro-auricular opening are now removed, and, with the exception of the lower edge, raised from the underlying bone by means of a small raspatory. The flap is now turned upwards upon itself, and its edges tucked under the undercut margins of the opening. In this way the epithelial surface of the flap, which formerly faced outwards, now faces inwards towards the antro-tympanic cavity. A few stitches are inserted to keep the flap *in situ*, and to approximate the edges of the raw surface from which the flap was dissected, while the raw surface itself is either allowed to granulate or is covered with a skin graft.

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[1] *Centralblatt für Chirurgie*, 1898, No. 46.

When it is not possible to undermine the edges of the opening, the operator should simply remove the epithelium, and suture the edges of the flap to the raw surface thus produced.

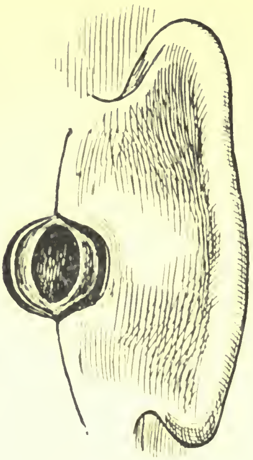

Fig. 164. The Passow-Trautmann operation.

First step. Separation of the skin and periosteum from the underlying bone by means of a circular incision around the post-auricular fistula.

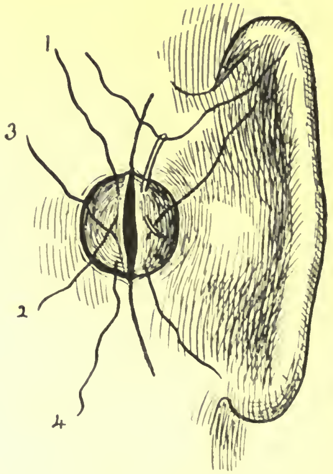

Fig. 165.—The Passow-Trautmann operation.

Second step. The sutures 1, 2 and 3, 4 are to be tied to the opposite sutures to bring the edges of the periosteum together.

When a large amount of scar tissue is situated around the retro-auricular opening, it may be necessary to dissect the flap from its upper or posterior margins, or to take it from the posterior surface of the concha.

2. *Passow-Trautmann Operation.*[1]—A circular incision is made about an eighth to a quarter of an inch from the edges of the fistulous opening, and the periosteum and skin thus included are separated from the underlying bone (Fig. 164). The edges of the periosteum thus exposed are then united with catgut sutures (Fig. 165). Finally, the skin around is freely loosened, and its edges united by three or four ophthalmic gut or horse hair sutures (Fig. 166).

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[1] *Zeitschrift für Ohrenheilk.* Bd. xxxii. p. 224.

3. *Alexander's Operation.*—A large flap is fashioned from the posterior surface of the auricle in front of the fistulous opening, and a smaller posterior flap from the skin of the mastoid process. These two flaps are turned over and united by sutures. The skin surrounding the opening is then freely loosened, drawn together, and sutured.

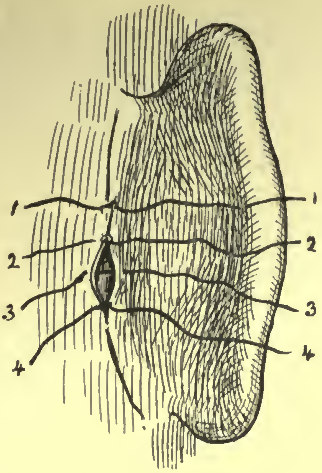

FIG. 166.—The Passow-Trautman operation.
Third step. Closure of the incision in the skin.

CHAPTER XXVI

MALIGNANT AND SYPHILITIC DISEASE OF THE MIDDLE-EAR CLEFT

Malignant Disease of the Middle Ear.—Malignant disease of the middle-ear cleft occurs either in the carcinomatous or sarcomatous forms, the former being more frequent in middle life, the latter in children or young adults. It may arise in any portion of the tubo-tympanic axis, the commonest sites, however, being the cavum tympani and the naso-pharyngeal orifice of the Eustachian tube. It may also invade the middle-ear cleft as the result of extension from adjoining structures, *e.g.* parotid gland, basi-sphenoid, etc. The previous existence of chronic middle-ear suppuration or temporal-bone caries is held to be one of the chief exciting factors. In two cases of middle-ear carcinoma seen by the writer it would appear to have originated as the direct outcome of injury. The symptoms which attract attention to the real nature of the morbid process are the persistence of intense pain, and the rapid recurrence of granulation tissue after removal. The discharge is also peculiarly foetid and pink in colour, while spontaneous haemorrhage is not unusual. Facial paralysis is also an early symptom in many cases. Enlargement of the peri-auricular glands is, however, a late phenomenon. Invasion of the surrounding temporal bone is followed by involvement of various cranial nerves in the posterior fossa.

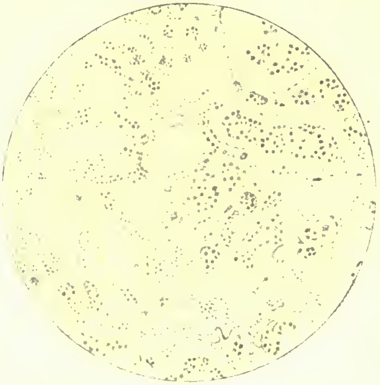

Fig. 167.—Alveolar epithelioma of middle ear, which started from the Eustachian ostium. Obj. $\frac{1}{4}$ in.

Of the different forms of carcinomatous disease of the middle-ear cleft epithelioma is the most common, of which the writer has seen 6 cases, 4 starting in the tympanic mucosa, and 2 in the isthmus tubae.

Another type which has occasionally been noted is alveolar carcinoma (Fig. 167). The position of the growth, the early involvement of surrounding bone, and the impossibility of effecting its entire removal, generally render operation useless. To allay the severe pain complained of morphia should be given at an early stage, and in full doses. Aspirin also affords temporary relief. When the growth has invaded the *pars mastoidea* and severe pressure pain is complained of, relief may be obtained by an extensive removal of the cortex. Death takes place either as the result of exhaustion, sepsis, meningitis, thrombosis of the lateral sinus, or erosion of the internal carotid artery.

Metastatic malignant disease of the temporal bone is exceedingly rare.[1]

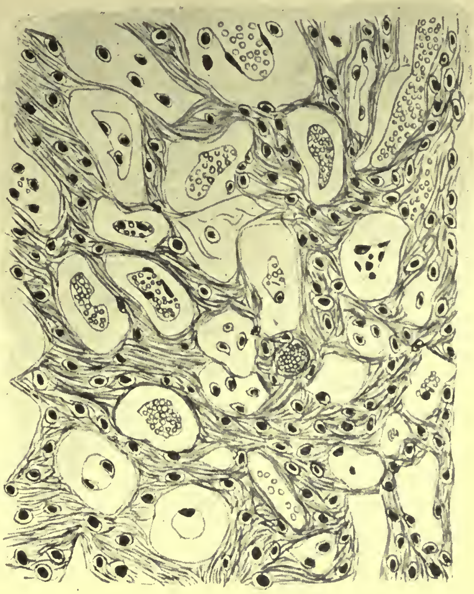

FIG. 168.—Angio-sarcoma. Obj. $\frac{1}{6}$ in.

Sarcoma of the middle ear, although also distinctly rare, is more frequently met with than epithelioma, and is mostly of the endothelial type. It is, as a rule, met with in children and young adults. It runs a rapid course, is accompanied, and probably preceded by suppuration and by the formation of exuberant granulation tissue of a grey sloughy appearance, which recurs almost as quickly as it is removed, by spontaneous haemorrhage, by invasion of the cellular spaces of the petro-mastoid, and by progressive asthenia. Enlargement of the peri-auricular glands is a comparatively late symptom, being due to sepsis and rarely to extension of the growth.

Suspicion should be excited in a case when the polypoid mass, as seen in the meatus, presents a grey, sloughy appearance, when it recurs rapidly after removal, and when its presence is accompanied by severe pain. In all such instances a microscopic examination of a portion of the growth should be made (Fig. 168).

Treatment.—Operative treatment is but palliative. An extensive post-aural operation should be performed, sacrificing if necessary the facial nerve and the internal ear with the object of prolonging life. In obviously inoperable cases removal of the mastoid cortex affords relief.

The injection of Coley's fluid has been tried by the writer in two inoperable cases, but without satisfactory results.

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[1] Alt, *Journal of Laryngology*, xvii. p. 137.

Otitis Media Suppurativa due to Syphilis.—Syphilitic infection of the middle ear is characterised by rapid destruction of the tympanic mucous membrane and membrana tympani, and by a tendency to invasion of the osseous walls of the cavity and involvement of the internal ear. It may be the result of a naso-pharyngeal catarrh, extension taking place *per tubam*, coincident with the breaking down of a specific granuloma in the cavity. It is very rarely due to a primary chancre of the pharyngeal orifice of the tube, but may not infrequently be met with as the outcome of cicatricial stenosis from gummatous ulceration of the lateral naso-pharyngeal wall, adhesions, etc.

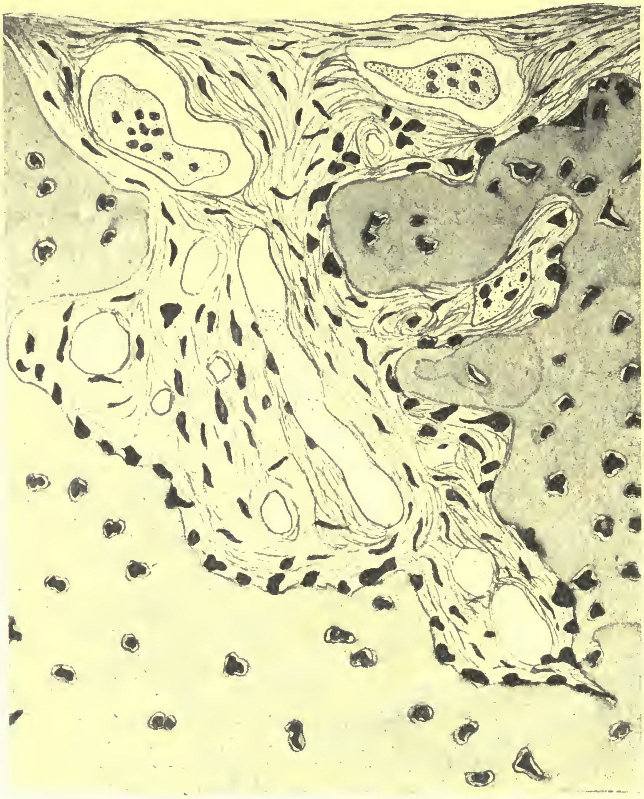

FIG. 169.—Myeloid sarcoma from mastoid. Obj. $\frac{1}{6}$ in.

The objective indications of the disease are similar to those of other forms of suppurative otitis media, although multiple perforations have been noted as occasionally occurring. In many cases the deafness is severe and is due to a simultaneous implication of the internal ear. Extension to the petro-mastoid or to intracranial structures results at times.

The diagnosis of the actual syphilitic nature of the lesion is, however, only to be arrived at when other evidences of syphilis are present, and when there is rapid destruction of the contents of the middle ear and early implication of the labyrinth. In any doubtful case the Wassermann reaction should be employed. Microscopical examination may establish the presence of a syphilitic granuloma (*v.* p. 276).

The prognosis is good provided that the case be seen early, and that anti-syphilitic treatment is adopted. In elderly and debilitated subjects, and in those cases where bone lesions are present, it is unfavourable.

Treatment.—Local treatment should be conducted upon the principles underlying the treatment of any ordinary case of suppurative middle-ear catarrh, alcoholic or aqueous solutions of mercurial salts being especially serviceable when used in the form of ear drops. General anti-syphilitic treatment should be employed at the same time, and abstinence from alcohol and tobacco enjoined.

The use of Salvarsan is specially indicated in this condition.

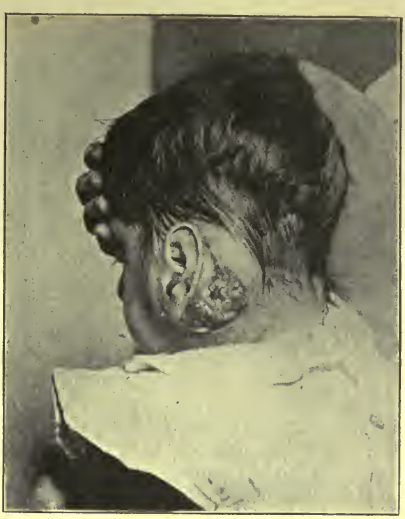

Fig. 170.—Sarcomatous growth springing from the dura covering the tegmen antri, and invading the middle-ear cleft.

CHAPTER XXVII

FACIAL PARALYSIS

The Facial Nerve. — Paralysis of the facial nerve may occur either independently of any morbid affection of the ear, or in association with, or as the result of ear disease, in which latter case it is due to some lesion of the middle or internal ear. It is, as a rule, met with as a result of chronic suppurative otitis media, although it is occasionally, more especially in children, due to an acute otitis media. It is often also an early symptom in tuberculous meningitis. It may be unilateral or bilateral.

Dehiscences in the bony covering of the aqueductus Fallopii, which are occasionally found, explain in many cases the onset of facial paralysis in acute otitis media. In chronic suppurative otitis media caries or cario-necrosis of the bony walls of the aqueduct, with exposure of the sheath of the nerve, explains its frequent occurrence. In tuberculosis of the temporal bone it is frequently an early symptom; in some cases it may be the first indication of the presence of disease.

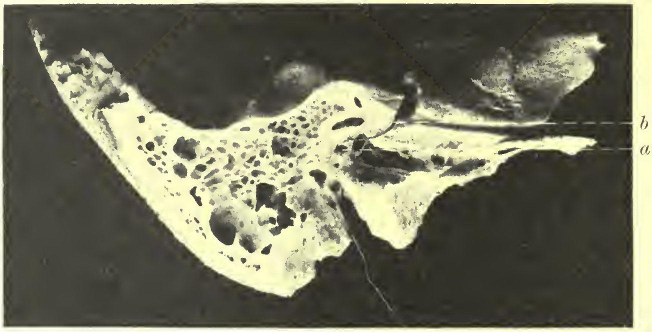

Fig. 171.—Section of a pneumo-diploetic temporal bone, showing the course of the facial nerve (represented by a wire), and its relation to the fenestra ovalis (*a*) and the external semicircular canal (*b*).

In purulent labyrinthitis it may also occur as an early symptom, and may be the result of an acute purulent lepto-meningitis, the inflammatory process spreading along the sheath of the nerve by way of the internal auditory meatus. Other causes are fracture of the base of the skull, growths springing from the sheath of the nerve and exerting pressure upon its trunk, malignant disease of the external, middle, or internal ear, intra-cranial abscess, and gross lesions of the cerebellum. It may also occur several days after a radical operation due to the tissue of repair pressing upon the exposed nerve. In such a case it is usually transient.

The nerve is also at times injured during the extraction of a foreign body wedged in the external meatus or middle ear, especially when attempted by an inexperienced operator and without due illumination of the field.

During the performance of an ossiculectomy, more especially when extracting the incus, the nerve is liable to injury.

More frequently, however, it is injured during the performance of the radical mastoid operation at the moment when "the bridge" is being removed, or when the facial spur is being levelled down (Fig. 172), or when curettage of the inner wall of the tympanum is being performed.[1]

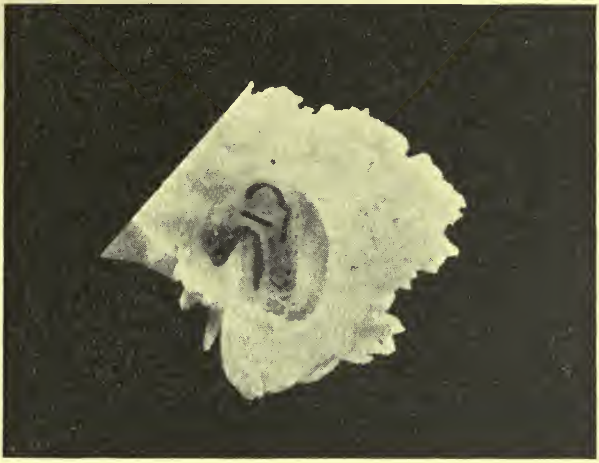

FIG. 172.—Temporal bone, showing the relation of posterior meatal wall to the aqueduct of Fallopius.

During the removal of sequestra and granulations around the nerve injury may likewise be inflicted.

When operating for the relief of labyrinthine suppuration the greatest care should be exercised otherwise the nerve is liable to injury.

Too tight packing of the antro-tympanic cavity, the introduction into the meatus of drainage tubes, either hard or soft, haemorrhage, or exudation into the middle ear by exerting undue pressure upon an exposed nerve may produce paralysis, which fortunately, however, is, as a rule, of a temporary character.

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[1] To lessen the risk of injurying the facial nerve during operative procedures use may be made of H. E. Jones' landmark, "if a plane be drawn from the prominence of the external semicircular canal to the highest point of the floor of the meatus, and parallel antero-posteriorly with the antro-tympanic axis, everything external to it may be freely removed, while everything within must be treated with the greatest respect" (*Journal of Laryngol. and Otolog.* June 1903).

In infants and very young children the nerve may be injured at its point of exit from the stylo-mastoid foramen should the incision for the relief of mastoid suppuration be carried beyond the apex of the mastoid process and at the same time be made too deeply, from osteomyelitis, or from inflammation of the parotid gland in association with acute otitis media.

When paralysis of the facial nerve is due to middle or internal ear disease it occurs upon the same side as the primary lesion; when of cortical origin, or due to a lesion of the internal capsule, upon the opposite side.

Symptoms.—The symptoms due to paralysis of the facial nerve vary in intensity and in situation according to whether the whole thickness of the nerve is affected or merely isolated bundles of fibres, the exact location of the lesion, the exciting cause, and its duration.

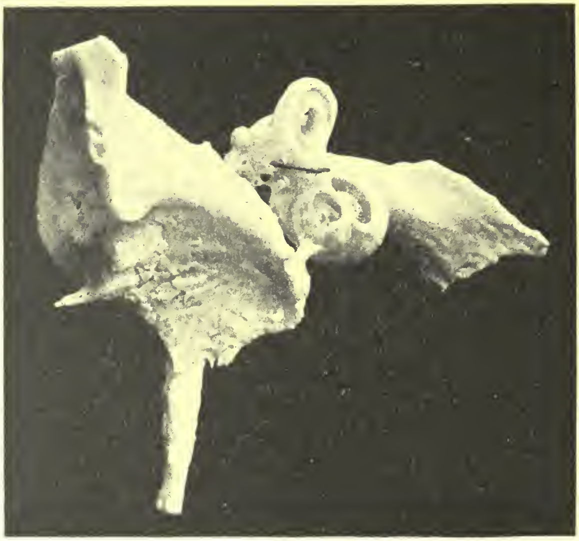

FIG. 173.—Temporal bone, showing opened-up cochlea and the relation of the facial nerve (represented by a thin wire) to the middle-ear cleft.

It is interesting to note that all the special senses are more or less interfered with in paralysis of the seventh nerve. The olfactory functions may be impaired by paralysis of the labio-nasal muscles, for the alae being collapsed the air column can no longer be directed to the olfactory area by the act of sniffing. Further, an unnatural dryness of the lower meatus follows diversion of the lachrymal flow, resulting often in very troublesome accumulation of "crusts" in that region.

Owing to involvement of the orbicularis palpebrarum the eyelids are improperly closed, their slight inward horizontal movements being arrested, the tensor tarsi cannot compress the lachrymal sac, hence secretions are no longer carried through the nasal duct but escape on to the cheeks—epiphora. This may be followed by conjunctivitis, and even corneal and scleral troubles.

The sense of taste is impaired directly through paralysis of the chorda tympani, directly through impaired secretion, and indirectly by limited mobility of the buccinator and labial muscles which will also modify articulation.

The sense of hearing, although its impairment is chiefly due to collateral causes, shows imperfection in accommodation for certain sound waves—oxyakoia (Roux)—hypersensibility to all sounds, together with an increased appreciation of low tones (Lucae), phenomena all of which are due to paralysis of the stapedius, and may be defined when the degree of lesion permits of clear differentiation.

When occurring several days after a radical operation, recovery may be safely anticipated.

The paralysis may appear quite suddenly, or it may commence gradually with twitchings of certain muscles followed by their complete inaction. During repose the paresis or paralysis of the facial muscles may not be much in evidence. The acts of talking, laughing, crying, whistling, frowning, etc., reveal, however, the inactivity of certain muscles or groups of muscles. In a typical case of facial paralysis of otitic origin the muscles of the same side of the face are affected. There is partial or complete inability to close the eyelids of the same side, with the result that the cornea and sclerotic are unduly exposed, and, in course of time, become ulcerated. The mouth is drawn over towards the sound side, and the tongue, when protruded, is similarly affected.

The normal folds and furrows of the same side of the face become obliterated, more especially the folds of the forehead and naso-labial furrows. Hence the face presents an expressionless aspect. There is complete inability to whistle, or even to place the lips in the position for whistling.

The exact location of the lesion is of great diagnostic importance. Disturbance of the sense of taste and inactivity of the salivary glands upon the affected side indicate that the lesion is situated between the point at which a branch of the nerve is given off to the stapedius muscle and the point of exit of the nerve at the stylo-mastoid foramen. When, however, the lesion is situated between the geniculate ganglion and the point of emergence of the branch to the stapedius muscle there is, in addition to anomalies of taste, persistent tinnitus with increased perception of low tones due to involvement of the stapedius muscle.

When the lesion is above the geniculate ganglion no disturbance of taste is noticed, owing to the fact that the chorda tympani nerve leaves the ganglion through the great superficial petrosal to join the fifth nerve.

In the early stages of facial paralysis the electrical reactions of the facial muscles with both Galvanic and Faradic currents are diminished. Later on the Galvanic reaction is somewhat intensified, while the Faradic remains diminished. Should there, however, be no response to Faradic stimulation, the outlook is grave.

When recovery is taking place the myo-electric reaction becomes greater, while the neuro-electric becomes less.

Bilateral paralysis of the facial nerve is rare. It may be due to an intra-cranial lesion, or, in quite exceptional cases, to bilateral middle or internal ear disease (Fig. 174).

Prognosis.—In the otitic type of facial paralysis the prognosis depends upon (1) its causation, (2) its duration, and (3) the presence or absence of muscle degeneration.

When the paralysis is due to haemorrhage into the sheath of the nerve, or pressure upon it, the prognosis is good, provided that free drainage is effected; when due to cario-necrosis much depends upon whether it is possible to remove the existing bone lesion, and upon how much damage has already been inflicted upon the nerve. The prognosis is better in non-tuberculous than in tuberculous cases.

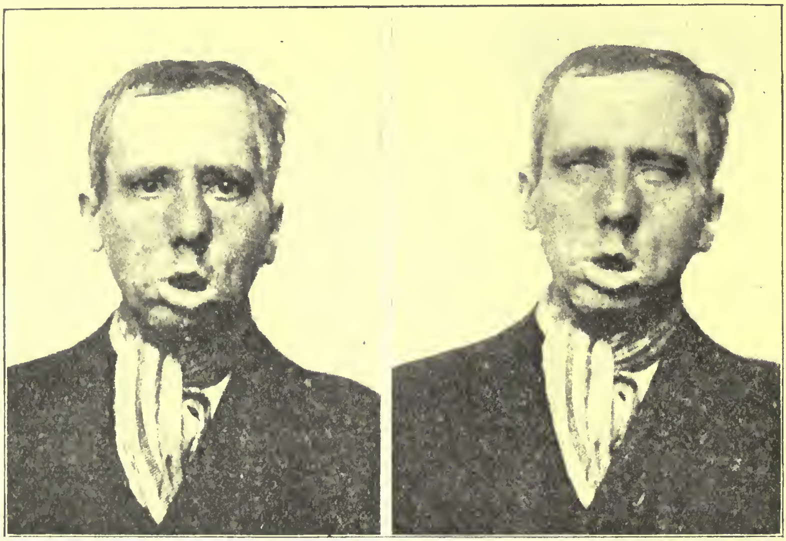

FIG. 174.—Bilateral facial paralysis due to bilateral chronic purulent otitis media.

When the paralysis is due to severe surgical trauma complete recovery is comparatively rare owing to the fact that granulation tissue is prone to grow between the severed nerve ends. Provided, however, that the cut ends of the nerve are placed in accurate apposition, complete recovery is quite possible.

Treatment.—In the treatment of facial paralysis the first duty is to remove the cause if possible. Thus in non-suppurative cases any exudation within the tympanic cavity should at once be drained off, and relief from pressure afforded as soon as possible. In suppurative cases complicated with cario-necrosis, granulations, etc., removal of all disease surrounding the nerve should be effected when possible, and free drainage maintained.

Counter-irritation over the mastoid process and iodide of potassium internally are at times of some value. In syphilitic labyrinthitis, especially if of recent origin, the subcutaneous injection of nitrite of pilocarpine should be tried.

In order to prevent degeneration of the facial muscles electrical stimulation with the Faradic current should be commenced at an early stage.

In cases of persistent facial paralysis, provided that the muscles of the face do not show any reaction of degeneration, an attempt should be made to restore the function of the peripheral end of the facial nerve by joining it up to the central end of a healthy and neighbouring nerve.

An anastomosis may be made with—

1. The spinal accessory nerve—facio-spinal anastomosis.
2. The hypoglossal nerve—facio-hypoglossal anastomosis.
3. Both spinal accessory and hypoglossal nerves.

The advantage of selecting the spinal accessory nerve is that it is easily exposed and picked up on its way to the sterno-mastoid muscle; its disadvantage is that atrophy of the sterno-mastoid and trapezius muscles results with consequent drooping of the shoulder. A further objection urged against facio-spinal anastomosis is that in order to put the muscles of the face into play the shoulder has first of all to be raised.

Facio-hypoglossal anastomosis is favoured by many surgeons from the fact that the cortical centres of the facial and hypoglossal nerves are situated in close proximity to one another, and that consequently association movements are more co-related and intimate; the main disadvantage being that palsy and atrophy of one-half of the tongue results.

Anastomosis may be effected by an end to end union of the peripheral portion of the facial nerve with the central end of the divided spinal accessory or hypoglossal nerve, or by lateral implantation of the peripheral end of the facial nerve into the spinal accessory or hypoglossal nerve.

To expose the facial nerve an incision is made along the anterior border of the sterno-mastoid muscle, commencing from 1 to 2 centimetres above the mastoid apex, and continued downwards to a point on a level with the upper border of the thyroid cartilage. The skin, superficial fascia, and platysma muscle are cut through and all bleeding points clamped. The deep cervical fascia is then divided, and the anterior border of the sterno-mastoid muscle exposed and drawn backwards. By so doing, the posterior border of the parotid gland is exposed. The nerve is now looked for at its entrance to the gland, usually 1 centimetre above and 1 centimetre internal to the mastoid apex. To facilitate its discovery and at the same time to secure a greater length of nerve, the apex of the mastoid process may be removed, and the nerve traced upwards as it lies in its bony groove. The facial nerve is now lifted from its bed and two fine sutures passed through its sheath. If necessary, its end may be freshened by cutting it across with a sharp knife. During all subsequent proceedings the nerve should be very gently handled and controlled by means of the silk sutures.

Facio-Accessory Anastomosis.—The spinal accessory nerve is now sought for as it enters the under surface of the sterno-mastoid muscle immediately under the deep cervical fascia and about 5 centimetres below the apex of the mastoid process, a useful guide to its position being the transverse process of the atlas. The nerve is here covered by the posterior half of the digastric muscle.

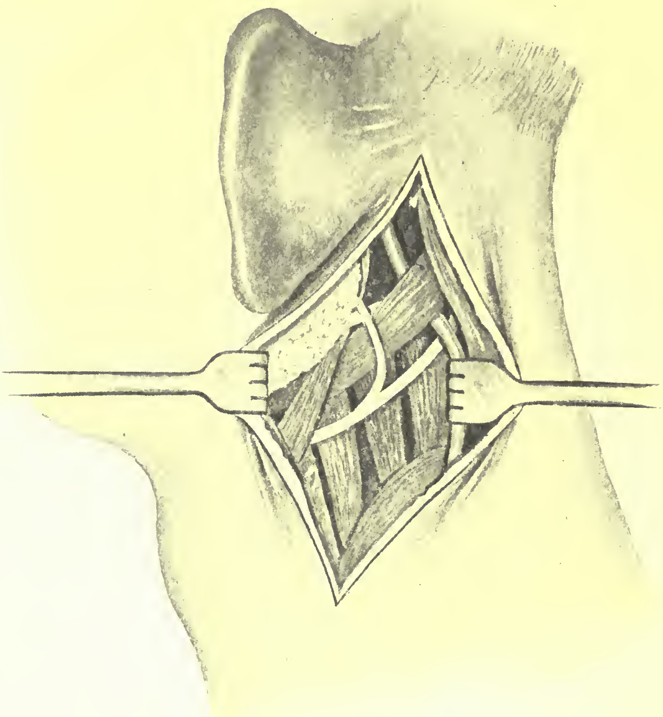

FIG. 175.—Facio-hypoglossal anastomosis, showing the peripheral end of the facial nerve united to the main trunk of the hypoglossal nerve (semi-diagrammatic).

Two silk sutures are now passed through its sheath, and it is divided with a sharp knife close to its point of entry into the under surface of the sterno-mastoid muscle. The central end of the spinal accessory and the peripheral end of the facial are then brought into intimate apposition and the silk sutures carefully tied.

A light dressing should then be placed over the exposed nerves, the edges of the skin incision being subsequently brought together by sutures, or a piece of Cargile membrane or gold-leaf may be wrapped round the apposed nerves so as to prevent the ingrowth of granulation tissue or the formation of adhesions, the rest of the wound being at once sutured.

Facio-Hypoglossal Anastomosis.—The facial nerve is exposed as previously described. The hypoglossal is now sought for as it turns round the occipital artery to cross the external carotid artery on its way to the tongue, the lower edge of the posterior belly of the digastric muscle serving as a useful guide. The occipital artery may frequently be recognised by feeling its pulsation with the finger. The internal jugular vein should now be looked for at the inner side of the operation area and when found drawn inwards. The hypoglossal and vagus nerves will now be seen, the former as it works round the occipital artery, and the latter as it passes downwards in the carotid sheath (Fig. 175). Two fine silk sutures are then passed through its sheath, and the nerve is divided with a sharp knife in such a position as to permit of the easy approximation of its central end to the peripheral end of the facial. The perineural sutures are now tied and the wound dressed as in cases of facio-spinal anastomosis (Fig. 176).

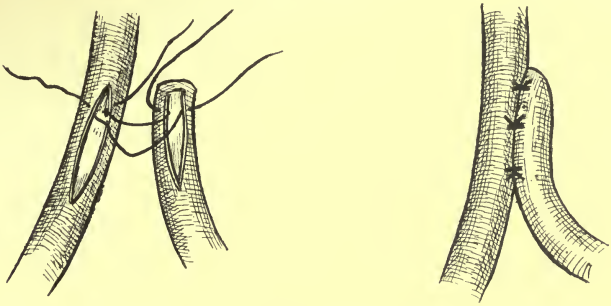

Fig. 176.—Facio-hypoglossal nerve anastomosis. The sutures are passed through the sheath of the nerve, and the divided facial nerve is implanted in a longitudinal slit in the hypoglossal nerve.

If lateral implantation of the peripheral end of the facial into either the trunk of the hypoglossal or spinal accessory be decided upon, a longitudinal slit is made, or a small segment of the nerve is removed, so as to permit of the cut end of the facial being firmly fixed into the selected nerve. The perineural sutures previously introduced are carefully tightened up and dressings applied as previously described. To ensure primary union perfect asepsis of the field of operation is essential.

In the event of the facial being injured or divided at the time of operation, Sydenham[1] and Marsh[2] recommend a careful approximation and accurate adjustment of the central and peripheral ends of the nerve

[1] *British Med. Journal,* May 8, 1909.

[2] *Ibid.* June 5, 1909.

in the Fallopian aqueduct. Restoration of function will in all probability result. If, however, the injury has not been recognised at the time of operation, the wound should be re-opened at the earliest possible opportunity and approximation effected. An interval of from three to four months should then be allowed to elapse in order to observe if restoration of function results. Should it fail to do so, a facio-spinal or facio-hypoglossal anastomosis should be performed.

To effect this accurate approximation the trunk of the nerve is laid bare in the Fallopian aqueduct, its torn ends teased into position, and strands of chromic catgut placed round them or inserted through the torn ends. The exposed portions of the nerve are protected by a piece of rubber tissue.

After Treatment.—Daily massage of the facial muscles is required, together with the application of the constant current and the internal administration of strychnia.

In the majority of cases when complete asepsis has been maintained, recovery to a greater or lesser extent takes place, associated movements of the tongue or shoulder muscles gradually becoming disassociated, and voluntary control of the previously paralysed muscles effected.

Complete recovery of movement of the muscles of expression and emotion has, however, not been obtained until quite recently. Ballance[1] has, however, solved this problem by advocating and carrying out a facio-hypoglossal anastomosis, in which an anastomosis was also made between the spinal accessory and the distal segment of the divided hypoglossal nerve. After the facio-hypoglossal anastomosis had been completed, the spinal accessory nerve was found and split longitudinally for about two inches. One-half of the nerve was divided transversely at the distal peripheral end of the slit. The portion of spinal accessory so raised up was united end to end with the peripheral end of the divided hypoglossal.

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[1] *Lancet*, June 12, 1909.

CHAPTER XXVIII

TINNITUS

The word Tinnitus, although strictly meaning a tinkling (L. *tinnio*) sound, is applied to all subjective abnormal sensations of sound. It is a symptom and not an aural disease, nor is it a symptom *sui generis.* It may be only a trivial and transient phenomenon, or it may be the first indication of important disease of the nervous, renal, vascular, or other systems. It is not necessarily attended by disease of the auditory apparatus. It is often a psychic manifestation of the greatest interest, especially when it persists long after the auditory elements, central and peripheral, are apparently destroyed, and the patient is insensible to every known acoustic test.

It is said to occur reflexly by irritation of any afferent cranial nerve. This dictum, however, is difficult to accept. Tinnitus is essentially a paraesthesia of the auditory perceptive mechanism, and may be referred to the ear, to any region of the head, or, more rarely, to the patient's surroundings.

In chronic cases the noises are generally described as being "in the head" rather than in the ears, and patients even attribute their deafness to the loudness of the noise in the head.

Character.—Tinnitus may be paroxysmal or continuous. It may be limited to a sudden explosion like gun-firing, or to an uninterrupted sound varying in intensity and pitch.

To enumerate all the different varieties of noises in the head as described by patients would be wearisome and superfluous, nor is it advisable to dogmatically associate any particular type of tinnitus with any separate variety of disease. It will, therefore, suffice to describe noises in the head according as they fall under one or other group. There seems to be no constant relation between the character of the tinnitus with either the nature or site of the lesion, although many attempts have been made to establish such. First we find the musical type which may simulate a bell, a whistle, or an organ-pipe. It has been compared to the singing of birds, the chirping of crickets, the movements of bat's wings, the purring of cats, and other such familiar sounds.

Although the sound may be musical and the tone may change, there is seldom any great variation or any actual tune except in purely psychical instances. In such cases voices are articulate, even actual sentences or phrases being heard, a most important feature in differential diagnosis.

Of non-musical sounds or noises there is infinite variety, depending to a great extent upon the habits and occupation of the sufferer, *e.g.* engine-drivers may complain of hissing, whistling, and screaming. One of the writer's patients repeatedly heard explosions like fog-signals. In such cases, doubtless, psychical influences may be in part responsible.

All noises, musical or otherwise, will vary in intensity according to the weather and atmospheric conditions, as also with the general health of the patients, and the various mental and physical conditions to which they are exposed.

Pathology.—The causes of tinnitus may arbitrarily be divided into two groups: (1) Those which are due entirely to morbid conditions of the auditory apparatus itself, and (2) those which affect it indirectly.

Of the first or *direct*, it is unnecessary to go into detail, as they have already been referred to. Suffice it to say that errors in ventilation and drainage, meatal or Eustachian, are perhaps of most frequent occurrence. Variations in the tension, mobility, or structure of the tympanic membrane, excursion of the ossicles, contraction of the intra-tympanic muscles, and the quality, quantity, and pressure of the labyrinthine fluids are all more or less responsible for tinnitus, with or without disturbance of hearing power and equilibrium. Spasm of the muscles, although only at present a presumptive phenomenon, may probably afford a reasonable explanation of tinnitus after careful exclusion of other causes. This is perhaps the chief condition, apart from vaso-motor effects, which can reasonably be accepted as due to reflex influences.

Of the second or *indirect* group of causes the majority are connected with the vascular supply of the auditory elements, central and peripheral. Any variation in the quantity, quality, and pressure of the blood and lymph stream may give rise to morbid sensations in that organ, varying both in character and intensity.

Although the vascular supply of the brain and labyrinth differs somewhat in its mechanism from that of the rest of the body, these organs must share in a great measure in the general changes in blood pressure, and to a full degree in the changes in its quality. Any sudden and extreme variation in arterial and venous pressure may at once give rise to tinnitus. This is well illustrated in cases of severe haemorrhage, as in parturition, haemoptysis, accidents, sudden splanchnic paralysis, etc. In persistently high arterial pressure and venous plethora from cardiac or pulmonary causes tinnitus is often a constant symptom. It may also be a forerunner of, or an attendant upon cerebral apoplexy.

Changes in the quality of the blood causing tinnitus are seen in auto-toxaemia (intestinal or renal), and under the influence of drugs, poisons, foods, etc., such as quinine, salicylates, amyl nitrite, muscarine, snake bites, tobacco, alcohol, ptomaines, etc. These may act either selectively or indirectly through the vaso-motor system.

In specific fevers and various forms of septic infection or toxic phenomena, tinnitus, with or without deafness, is very common. It is also a prominent feature in various forms of renal disease, in myxoedema, in intra-cranial lesions, and it frequently follows exposure to noise as in railway travelling. Exhaustion succeeding a prolonged auditory effort and vibration may give rise to tinnitus either through the cochlear terminals, or by exhaustion of the accommodating mechanism as occurs in vision. Pregnancy, parturition, and prolonged lactation are peculiarly responsible, while epileptic patients suffer severely from tinnitus, when it occurs either as an aura or follows an attack.

Tinnitus, too, seems intimately associated with sclerotic changes in other regions as well as in the ear, for it is a prominent prodromal sign in various neuroses such as tabes and disseminated sclerosis. Children are much more rarely affected than adults.

Pathogenesis.—But little is known of the actual lesions responsible for tinnitus. But as it is so prominent a symptom in all sclerotic changes it is only reasonable to assume that it is set up by structural disturbance of the cochlear nerve or its terminations, central or peripheral. But it may be induced also by variations in the quality, quantity, and pressure of the blood, cerebro-spinal, or labyrinthine fluids without any known histological lesions, as in toxaemia.

It must be borne in mind that tinnitus may occur without any appreciable deafness, and further, that it may continue even after complete deafness has become developed.

It is reasonable to assume that any marked variation in the pressure and flow of blood through the carotid canal may give rise to entotic phenomena, since variations in flow through rigid canals are easily heard even at great distances by molecular conduction. Of this phenomenon we have a familiar illustration in the "water detective" with his "stethoscope" walking stick.

Differential Diagnosis.—The subject of tinnitus should have all the special senses carefully examined as well as the heart and vascular systems, the kidneys, and the digestive canal. The blood and urine may afford most valuable information, since various types of anaemia or the presence of sugar or albumen in the urine may reveal disease of organs other than the auditory, of which tinnitus is a striking and early symptom.

Close attention should also be paid to vestibular as well as to cochlear phenomena, including the caloric test.

A systematic bi-weekly record of pulse-pressure often affords most valuable evidence.

It is of the utmost importance to try to localise the seat of mischief, as to whether it is in the ear, the nerve, or the brain.

Prognosis.—The prognosis of tinnitus will depend chiefly upon its cause, its duration, and its type. If simply due to aural obstruction or to toxic influences removal of the cause affords rapid relief. The effect of a purge or emetic in cases of tinnitus due to gastro-intestinal irritation is striking, but when due to sclerotic lesions, tympanic, labyrinthine, or cerebral, the outlook is bad.

In antro-tympanic disease amenable to operation the forecast is generally favourable even in the presence of acute complications in the labyrinth. But when tinnitus belongs to the hallucination type, especially when attended by oto-sclerosis, the forecast is grave.

Treatment.—The relief of no symptom perhaps affords greater satisfaction to the sufferer than does that of tinnitus. Every aurist is familiar with the statement, "Stop the noises, and I can bear the deafness." In acute cases this is easily and quickly effected by removing the meatal and Eustachian obstruction, and so restoring ventilation and drainage to the middle ear; but in chronic cases it will be only palliative and temporary. The first desideratum is to equilibrate blood-pressure. This may be effected by small doses of grey powder, or one-fifth grain of calomel with each meal, and by saline aperients, while gastro-intestinal toxaemia may be counteracted by similar measures supplemented by creasote or salol combined with careful dietary, and, if necessary, abstention from alcohol and tobacco. Relaxation of the tympanic membranes may be remedied by galvano-puncture, or by painting with contractile collodion.

Counter irritation is only of value in psychical cases which are amenable to suggestion. Turkish baths and pilocarpine are indicated in cases of high arterial pressure with a gouty and arthritic diathesis. Among operative measures are to be mentioned tympanotomy, ossiculectomy, section of the cochlear nerve, obliteration of the labyrinth, and lumbar puncture. High frequency currents have afforded temporary relief in neurotic cases.

Amongst drugs there are many which do afford relief, although often only a temporary one, and their choice must obviously be guided by the initial cause. Bromide of ammonium is, as a rule, preferable to bromide of potassium in neurotic cases, and is of particular value when combined with iodide of potassium. Pilocarpine and amyl nitrite should be used with caution in arterio-sclerotic and renal conditions. Zinc phosphide, with or without arsenic, affords great and prolonged relief in anaemic and neurotic cases.

When arterial pressure is low, adrenalin is indicated. In cases of myxoedema and exophthalmos thyroid extract occasionally proves useful.

Motor Neuroses of the Auricle and Tympanum.—Motor neuroses affecting the ear may be of *spastic* or *clonic* type.

Spastic contractions of the muscles of the auricle occur rarely, and as part of a general neurosis. They are most frequently observed in conjunction with spasm of the facial muscles.

Spastic contractions of the intra-tympanic muscles, the tensor tympani, and more rarely the stapedius, are fairly frequently met with, and cause subjective sensations of a crackling nature and at times definite objective indications. Upon examination during contracture of the muscle a movement of the membrana tympani may be seen to take place, and if an ear manometer be inserted in the external meatus the fluid will be observed to fall on account of the negative pressure induced.

In cases of blepharospasm various noises of a rushing or clicking character are at times complained of, and are induced as the result of spasm of the stapedius muscle which is supplied by a twig from the facial nerve.

Cases of *clonic* spasm of the muscles of the Eustachian tube have also been described by various authors. In some of the cases crackling noises were produced, occurring simultaneously with contraction of the muscles of the soft palate, and which could be stopped when the velum palati was raised up with the finger. These noises are objective as well as subjective, and are at times easily heard by the observer either by means of an auscultation tube or through the patient's mouth.

Spasm of the tympanic muscles may not only produce tinnitus, but also vertigo and slight temporary deafness.

CHAPTER XXIX

THE INTRA-CRANIAL COMPLICATIONS OF MIDDLE-EAR DISEASE

1. **Anatomical and General Considerations.**—The dura mater covering the temporal bone is intimately attached to it at certain points, and is continuous with the endosteum. In other parts it is more loosely applied, and forms the epidural space. The chief points of close attachment are at the margins of the sinuses, the internal auditory meatus, the aqueductus

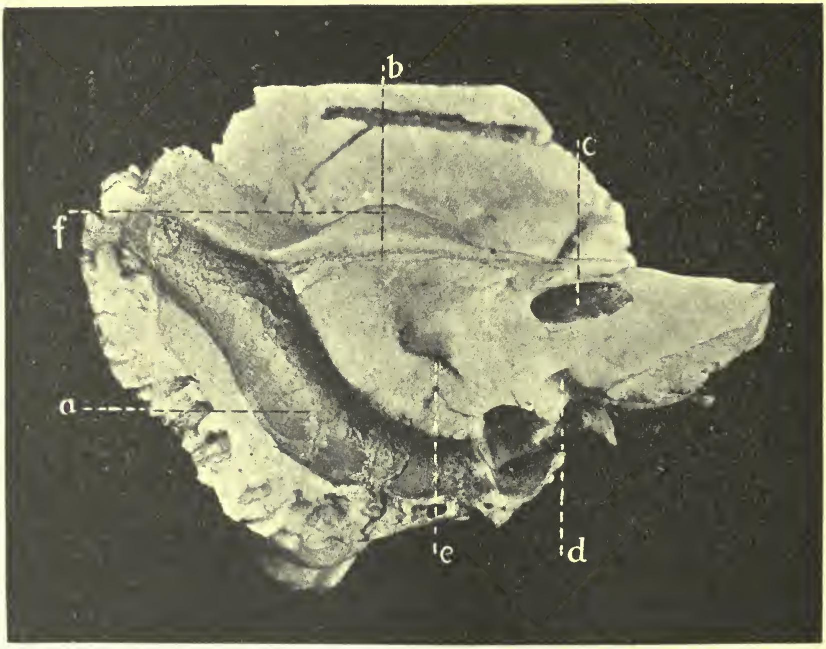

Fig. 177.—Inner surface of temporal bone. *a*, Groove for the sigmoid sinus; *b*, groove for the superior petrosal sinus; *c*, internal auditory meatus; *d*, aqueductus cochleae; *e*, aqueductus vestibuli; *f*, eminentia arcuata (superior semicircular canal).

vestibuli, the sutures, and the apex of the bone, where it forms a fossa containing Meckel's ganglion. Adjacent to this area and lying on the root of the *alisphenoid*, the *basisphenoid*, and the floor of the *sella turcica*, the dura mater is broken up into a loose arrangement of venous spaces, forming the cavernous and circular sinuses which are traversed by the 3rd, 4th, and 6th nerves. These sinuses are important, as they may be the seat of a septic sinusitis extending from the middle ear quite independently of any infection of the sigmoid and lateral sinuses.

The *lateral* sinus is included in the hinder border of the tentorium grooving the occipital bone and the postero-inferior angle of the parietal. It has a rudimentary connection with the primitive external jugular vein by means of the mastoid vein. From the angle of the parietal bone just at the entrance of the superior petrosal sinus it becomes the *sigmoid sinus*, running downwards and forwards in the sigmoid groove of the petromastoid bone, and, crossing the exoccipital bone, terminates in the jugular bulb, immediately beneath the antro-tympanic cavity.

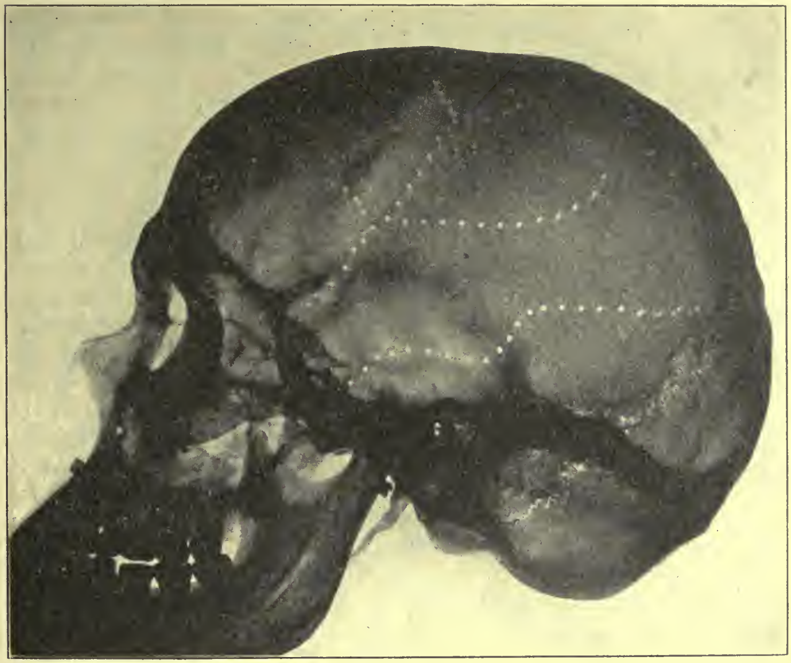

FIG. 178.—Radiogram of skull showing the position of the lateral sinus (sinus has been filled with bismuth paste). The dotted lines indicate the course of the middle meningeal artery.

In addition to several small veins from the labyrinth and adjacent parts of the pyramid, it receives the superior petrosal sinus at its commencement.

The *superior petrosal sinus* commences in the cavernous sinus below the 4th nerve; passing backwards and outwards over Meckel's space, it grooves the upper edge of the petrous bone, and opens into the sigmoid sinus at its junction with the lateral.

The *inferior petrosal sinus* begins in radicles connected with the cavernous sinus, and passing downwards and backwards in the sulcus overlying the petro-occipital suture, enters the anterior part of the jugular foramen, and empties into the jugular bulb. It receives veins from the cochlear and vestibular aqueducts, and from the floccular fossa.

Intra-cranial complications, both in infants and adults, occur much more frequently as the result of chronic infective middle-ear disease than as the outcome of acute suppuration. In the latter case, however, infants are more prone to intra-cranial infection, owing to a much freer communication between the tympanic and cranial cavities existing during early life. In acute primary pyogenic inflammation of the middle-ear tract the morbid process is almost invariably limited to its mucous membrane, and although often involving surrounding bone even in severe cases rarely extends to the brain cavity.

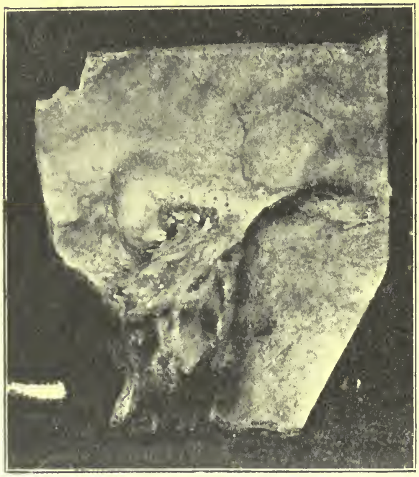

FIG. 179.—Temporal bone. Caries of tegmen antri and squamo-petrosal suture.

In chronic disease, on the other hand, long-continued suppuration leads to ulceration of the muco-periosteum of the infected area, with exposure and ultimate implication of the underlying bone, with the result that the existing septic process readily invades adjoining structures on the occasion of a superadded infection.

The tissues and organs most frequently infected are the meninges, the venous sinuses, the cerebrum, and the cerebellum, whilst in a certain proportion of cases a general blood infection results.

The thin plate of bone which forms the tegmen of the tympanum and antrum proves readily vulnerable to the ravages of pyogenic infection, with the result that fistulae of varying size, shape, and number develop. In many cases these fistulae are small and of a circular shape, in others they are large and irregular (Figs. 179 and 180). At times the roof of both tympanum and antrum is eroded, exposing a considerable area of dura mater lining the base of the middle fossa.

In other cases a number of minute erosions are discovered, producing a peculiar sieve-like appearance. Or the ulcerative process may extend backwards and perforate the posterior bony wall of the mastoid process, exposing the lateral sinus as it lies in the sigmoid groove. Extension may also take place towards the posterior wall of the pyramid, ultimately reaching the posterior fossa in the space between the internal auditory meatus and the groove for the lateral sinus or along the ductus endolymphaticus. In exceptional cases erosion of the bony floor of the tympanic cavity occurs, with exposure and infection of the bulb of the jugular vein. Erosion and perforation of the internal carotid artery may also occur. Pathogenic organisms may also reach the base of the brain or the anterior surface of the lateral cerebellar lobe by way of the internal ear. The dense bony capsule of the labyrinth is at times perforated as a sequel to chronic infective middle-ear disease, especially when complicated with the presence of an infected cholesteatoma. In many petrous bones there is a considerable amount of cancellous tissue around the labyrinth continuous with that of the mastoid element. Caries may at times be traced from the region of the *sinus tympanicus* below the labyrinth into the posterior fossa underneath the internal auditory meatus.

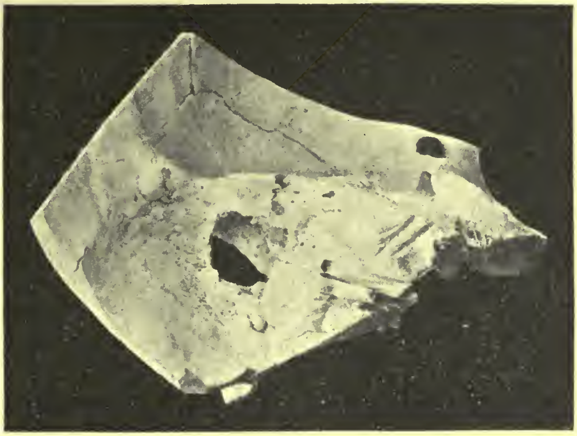

FIG. 180.—Temporal bone, showing extensive destruction of antro-tympanic roof.

The most frequent sites of perforation in such cases are the external semicircular canal, the fenestra ovalis, and the pars promontoria. Infective organisms having once reached the vestibular or cochlear portions of the internal ear, may readily pass along the peri-neural or peri-vascular sheaths of the vestibular or cochlear branches of the auditory nerve and artery to the base of the brain.

Erosion of the bony covering of the aqueductus Fallopii in its passage through the tympanum, by opening up and exposing the facial nerve, affords another channel along which pyogenic organisms may eventually reach the base of the brain.

The aqueductus vestibuli affords another, albeit comparatively rare, channel of infection.

Although in the majority of cases some pathological defect will be found in the osseous framework of the temporal bone through which pyogenic organisms have travelled, other routes are afforded by the numerous vascular and lymphatic channels which run between the mucosa of the middle ear and the base of the brain.

Infective organisms may also find their way through imperfectly ossified sutures, *e.g.* petro-mastoid, or through the membrana secundaria covering the fenestra rotunda, or through the annular ligament uniting the footplate of the stapes to the margins of the fenestra ovalis.

Disease within the posterior cranial fossa, except in those rare instances where, as the result of erosion of the superior semicircular canal, the meninges of the middle fossa become involved, is almost invariably due to infection by way of the internal ear.

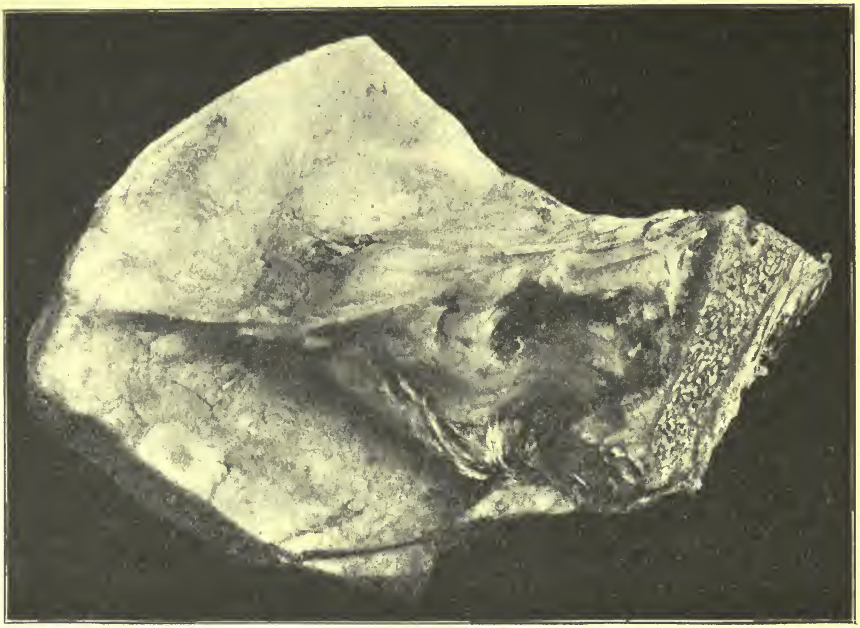

Fig. 181.—Temporal bone, showing carious erosion of the tegmen antri.

The particular intra-cranial complication produced depends upon several factors, the principal being the situation and extent of the osseous lesion and the pathogenicity of the invading organisms.

Three distinct types of complication occur: (1) inflammatory processes affecting the meninges; (2) suppurative lesions within the substance of the cerebral or cerebellar hemispheres; (3) infection of the intra-cranial venous sinuses and of the walls of the internal carotid artery.

Meningeal infection may be diffuse or localised, may attack the dura mater or the pia-arachnoid, or may be so diffuse as to cause a general inflammation of both coverings.

For the purposes of clinical differentiation the following types are recognised :—

1. Pachymeningitis.
2. Pachymeningitis interna circumscripta.
3. Pachymeningitis externa circumscripta syn. extra-dural abscess.
4. Leptomeningitis syn. pia-arachnitis.

Another type of meningitis, not of itself primarily septic, although owing its origin, as a rule, to the presence of some septic focus, in or around the middle ear, is *meningitis serosa* characterised by an excessive production of cerebro-spinal fluid and ventricular distension, and by symptoms indicative of increased intra-cranial pressure.

In a recent case of fatal cerebellar abscess, complicated with serous meningitis and distension of the lateral ventricles, the labyrinth was found full of pus. Spirochaetae were found in pus taken from the labyrinth and abscess cavity. Cerebro-spinal fluid drawn off by a previous lumbar puncture was found to be sterile.

Suppuration within the substance of the brain is usually local and circumscribed. In order of relative frequency the following types of brain suppuration are met with :—

1. Temporo-sphenoidal abscess.
2. Cerebellar abscess.
3. Encephalitis diffusa.
4. Metastatic abscesses; frontal, occipital, or pontine.

The various venous sinuses in relation—immediate or remote—with the septic ear or ears are liable to become infected, partly as the result of their contiguity with osseous lesions of the temporal bone, and partly owing to the transference of organisms from distant septic foci.

Clinically the following affections are recognised :—

1. Septic phlebitis of the sigmoid sinus.
2. Septic phlebitis of the jugular bulb.
3. Septic phlebitis of the petrosal and cavernous sinuses.[1]

Infection of any one sinus may lead to infection of all other intra-cranial sinuses, the pyogenic organisms frequently travelling against the blood-stream.

The intimate relation of the internal carotid artery in its passage through the temporal bone with the middle and internal ear, renders it liable to invasion at times ending in ulceration of its coats, with resulting fatal haemorrhage.

In many cases, however, two or more types of complication exist at one and the same time. Thus lateral sinus thrombosis is frequently associated with a perisinusal (extra-dural) abscess and meningitis, or an abscess of the cerebellum with thrombosis of the lateral sinus. In this way the symptom-complex becomes much marked, giving rise to great difficulties in diagnosis, treatment, and prognosis.

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[1] Recently 2 cases have occurred in the writer's practice in which death, due to acute septicaemia, followed operation. In each case the necropsy revealed pyophlebitis of the cavernous and circular sinuses only, with infective and partial destruction of the pituitary body.

2. Pachymeningitis Externa Circumscripta. Extra-dural Abscess.—As the result of osseous erosions around the middle ear and its accessory spaces, or as the result of direct transference of pathogenic organisms from an infected middle-ear cleft along vascular or lymphatic channels, pus may collect between the dura and adjacent portions of the temporal bone. The usual sites of such purulent collections are over the tegmen tympani or antri (Fig. 182), the groove of the lateral sinus, or that portion of the posterior surface of the pyramid situated between the internal auditory meatus and the groove of the lateral sinus. In this last situation the presence of an extra-dural collection of pus may be due to infection spreading along the *saccus endolymphaticus*, the result of extension of septic labyrinthine disease along the *aqueductus vestibuli*, as has been shown by Jansen and Horne. The existence of an endosaccular abscess is difficult to prove, but pus may be seen around the duct.

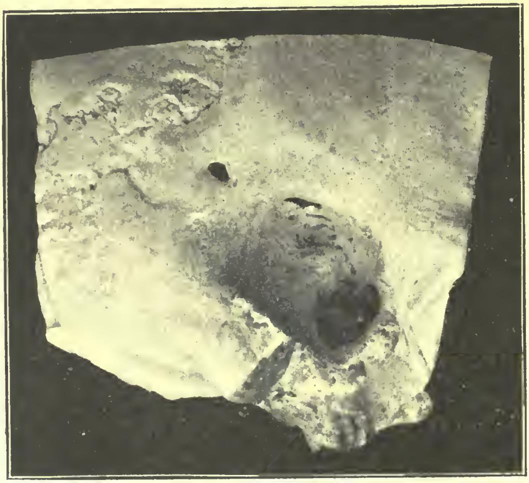

FIG. 182.—Temporal bone, showing carious erosion of tegmen antri, from a case of extra-dural abscess in which a complete post-aural operation had been performed.

The size of extra-dural abscesses varies greatly. At times they are quite small, at other times so large as to spread beyond adjacent sutural lines.

In early life an extra-dural abscess is most frequently a complication of acute otitis media; in adults it is secondary to chronic disease or to an acute exacerbation of chronic disease, and is most frequently found in the posterior fossa. When occurring in the course of chronic middle-ear suppuration it is due either to the presence of an acute exacerbation or to a septic cholesteatoma.

The bone underlying the abscess is frequently discoloured and carious. In exceptional cases the skull may be perforated, with the result that a gradual collection of pus takes place under the pericranium, constituting what is known as the "shirt-button abscess." In a case seen by the writer in a child aged twelve years, perforation of the skull-cap took place immediately behind the squamo-parietal suture, in another, a male patient aged twenty-nine, in the neighbourhood of the parietal eminence. The dura mater limiting the abscess cavity becomes gradually thickened and of the consistence of wash leather. The surface is frequently studded with exuberant buds of granulation tissue, which in cases of perforation of the tegmen tympani may hang down into the cavity of the middle ear, resembling ordinary polypi. Towards the periphery of the abscess cavity plastic exudation unites the dura to the underlying bone, thus limiting the extension of pus. The limitations of large extra-dural abscesses are largely governed by sutural lines. In exceptional cases the thickened and oedematous dura becomes perforated, the extra-dural abscess cavity communicating either directly with the subdural space, or with an abscess situated within the cerebrum or cerebellum.

Bacteriology of Extra-Dural Abscess.—Suppurative infection between the dura mater and the temporal bone may be briefly considered under three conditions.

1. As a primary acute affection, extending from the antro-tympanic cavity through the numerous vasculo-venous canals.
2. As a slow infective process by granulomatous infiltration of the bone itself.
3. As an acute exacerbation due to a superadded infection upon a chronic process.

The first occurs more frequently in childhood and is often associated with acute specific fevers such as measles, whooping-cough, scarlatina, and rötheln. It is usually due to a coccal invasion, the commonest forms being *streptococcus pyogenes*, *pneumococcus*, *meningococcus*, and the *diplococcus catarrhalis*. Pfeiffer's influenza bacillus has been credited with great responsibility for aural infections, but is not found alone in intra-cranial pus, being accompanied by one of the previously named coccal forms. The *bacillus septus* (Cautley's bacillus), a Gram + capsulated diplo-bacillus, so often accompanying severe "influenzal" colds, was found by the writer in one case in almost pure cultivation. In the second class infection is invariably poly-microbic. The pus found is often foetid, and in addition to the ordinary pyogenic bacteria, the following forms may be present: *streptothrix* (especially the acid-fast variety), *bacillus butyricus*, *bacillus proteus vulgaris*, *bacillus of tubercle*, *bacillus pyocyaneus*, *bacillus coli communis*, *bacillus subtilis*, *torulae*, *spirochaeta foetida*, fusiform bacilli, and many other bacteria familiar to the throat and mouth. In the third class any of the last mentioned bacteria may be found, together with the micro-organisms responsible for the production of the acute infection, such as *staphylococcus*, *streptococcus*, *bacillus pyocyaneus*, and *diplococci* of the first group.

Symptoms and Diagnosis.—The diagnosis of an extra-dural abscess is always a matter of considerable difficulty, and is frequently only made during the opening of the accessory cavities of the middle ear. Its presence may, however, be inferred, if in a case of acute otitis media or acute exacerbation of chronic otitis media, symptoms do not clear up after a thorough opening of the infected middle-ear tract. Such symptoms as persistent and severe pain over the temporal bone, high temperature, mental irritability, dizziness, nausea, and vomiting would serve to indicate the presence of some more deeply seated collection of pus.

In cases where the abscess is of such a size as to compress the brain the temperature falls to about normal, whilst the pulse becomes progressively slower, the normal ratio of 4 to 1 being no longer preserved. There is also progressive mental hebetude and somnolence, accompanied frequently by optic neuritis and horizontal nystagmus.

Paralysis of the sixth nerve has also been observed, and as a rule in cases following acute infection. In an analysis of 53 cases, Gradenigo[1] found it present 47 times in acute, and 6 times in chronic suppurative otitis media; J. S. Barr[2] in 2 cases following chronic suppurative disease. In all probability the inflammatory process extends from the middle ear to the apical cellular spaces of the pars petrosa (Fig. 183), which in a certain number of temporal bones are well marked, by way of the cells surrounding the tympanic orifice of the Eustachian tube and floor of tympanum, and so to the osseo-fibrous sheath of the nerve which lies in Dorello's space in close proximity to the apex of the petrous bone, or by invasion of the channels of communication which exist between the carotid canal and the apical cells.

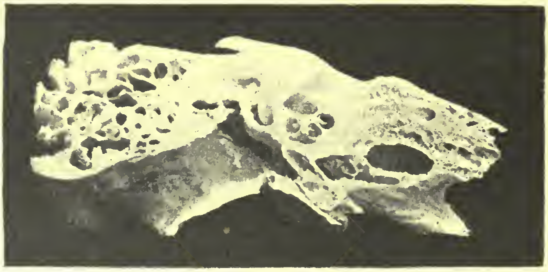

FIG. 183.—Horizontal section of temporal bone, showing apical (pars petrosa) cells.

When the abscess is of considerable size and situated in the posterior fossa, retraction of the head or torticollis may supervene. Lumbar puncture will show leucocytes and possibly bacteria, whilst a blood-count will reveal the existence of leucocytosis and an excess of eosinophiles.

When situated around the lateral sinus it may induce periphlebitis and symptoms of septic thrombosis. Pulmonary symptoms are also met with at times.

In a certain number of cases the sudden discharge of a large quantity of pus from the ear, followed by relief of all urgent symptoms only to reappear as the abscess cavity fills up again, is presumptive evidence of the presence of an extra-dural collection of pus. This alternate appearance and disappearance of urgent symptoms with the escape of large quantities of pus is looked upon by many observers as of great diagnostic importance.

Politzer lays stress upon the value of rarefaction of the air in the auditory meatus as an aid to diagnosis. In those cases where a fistulous tract leads through the tegmen tympani into the abscess cavity, rarefaction may cause the sudden appearance of large quantities of pus from between the buds of granulation tissue springing from the exposed dura mater.

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[1] *Archiv für Ohrenheilk.* vol. lxxiv.

[2] *British Medical Journal*, September 26, 1908.

Terminations.—Gradual accumulation of pus in an extra-dural abscess, especially if limited by adhesions, leads to erosion and subsequent perforation of the overhanging dura, with the result that pus leaks into the pia-arachnoid space, giving rise to a rapidly fatal leptomeningitis. In certain cases the slowly progressive character of the disease permits of the formation of adhesions between the pia-arachnoid and the underlying dura. Under such circumstances perforation, should it take place, leads either to a superficial ulcerative encephalitis or to the formation of a cerebral or cerebellar abscess.

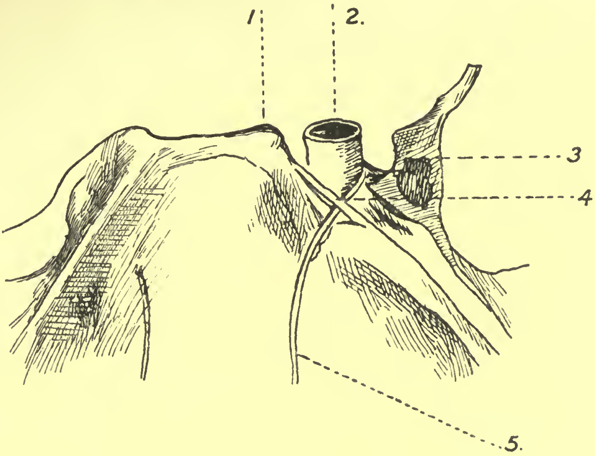

FIG. 184.—Dorello's space (after J. S. Barr). 1, Posterior clinoid process; 2, internal carotid artery; 3, dura mater reflected from apex of pars petrosa; 4, petro-sphenoidal ligament; 5, sixth cranial nerve.

Although such abscesses are often produced by the direct escape of pus through a perforated dura, they may arise simply from contiguity of tissue, pathogenic organisms being conveyed along vascular streams from the one structure to the other.

At times an extra-dural abscess disappears spontaneously after sequestration of the tegmen tympani or antri and the escape of its purulent contents through the middle ear.

If unrelieved, it may lead to a fatal result, from septic endophlebitis, general septicaemia or pyaemia (especially pulmonary), basic meningitis, or increase of intracranial pressure.

Treatment.—If during the course of an acute suppurative otitis media a diagnosis of extra-dural abscess be made, the dura mater should be exposed after opening up the cavity of the mastoid antrum; if during the course of chronic suppurative otitis media after the performance of the radical operation. In either case, sufficient bone should be cut away to expose the roof of the tympanum and antrum. Failing the discovery of an extra-dural abscess in either of these situations the groove of the lateral sinus should be exposed. Once having discovered the situation of the abscess, sufficient bone should be removed to permit of unimpeded drainage, care being taken at the same time to avoid the breaking down of any plastic adhesions which may have formed and which serve to limit its extension. After having cleansed the infected cavity a careful scrutiny of the dura should be made for fistulous tracts leading into the interior of the cerebral substance, for, as has been already remarked, such extra-dural abscesses are at times in direct communication with cerebral or cerebellar collections of pus. Should the dura be studded with exuberant granulations their removal may or may not be undertaken, or the whole of the infected region may be swabbed with pure carbolic acid. The removal of the focus of infection and the establishment of free drainage is, however, usually sufficient to effect a cure.

When a small fistula is discovered in the tegmen tympani or antri through which pus oozes, its enlargement should be accomplished by carefully chipping away all surrounding softened and discoloured bone.

In the event of the tegmen tympani not being perforated, but when it is desirable to expose the adjacent dura, its removal is readily effected by means of a gouge, care being taken to keep its direction parallel to that of the plane of the tegmen itself.

3. **Meningitis.**—Meningitis of otitic origin may be purulent, serous or plastic, acute or chronic, localised or diffuse. It may be limited to the base or may spread over the vault. It may attack the dura mater (pachymeningitis) or the meshes of the pia-arachnoid (lepto-meningitis), or may invade both membranes at one and the same time.

The most frequent causes of meningitis are extension of pyogenic infection:—

1. Through carious erosion of the temporal bone, the principal sites of selection being the tegmen tympani, the tegmen antri, the petro-squamosal suture, the groove of the lateral sinus, and the posterior surface of the pars petrosa between the groove for the lateral sinus and the internal auditory meatus.

2. Along the perivascular and perineural sheaths of the auditory and facial nerves and vessels in cases of labyrinthine suppuration.

3. Along the aqueductus vestibuli by way of the ductus endolymphaticus.

4. Along the perivascular sheaths of small blood-vessels and the fibrous trabeculae running between the tympanic mucosa and the membranes of the brain.

5. Along veins to the superior and inferior petrosal sinuses.

6. Along the petro-squamosal sinus (a vestigial remnant) which conveys blood between the tympanic mucosa and the meninges.[1]

Various other intra-cranial lesions may be associated with purulent meningitis, such as extra-dural, temporo-sphenoidal or cerebellar abscess, or thrombosis of the sigmoid sinus, and may so mask subjective symptoms and objective indications as to make an accurate diagnosis a matter of the greatest difficulty.

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[1] A. H. Cheatle, *Trans. Internat. Otolog. Congress*, London, 1899.

Uncomplicated meningitis is as frequently met with in cases of acute purulent otitis media as in cases of chronic disease in children, but less frequently in adults, the channels of infection being larger in early life.

In from 70 to 75 per cent of the cases the meningeal infection starts in the posterior fossa, in from 25 to 30 per cent in the middle fossa.

Pathology.—Acute infective meningitis of aural origin presents itself in two forms, serous and purulent, although there may be varying degrees between these two extremes. The process may be limited mainly to the base, as is so often seen when the infection is through the posterior fossa, or may involve the vault chiefly when the middle fossa is the channel.

The *serous* type is characterised by the exudation of a slightly opaque thin fluid in considerable quantity, sometimes mixed with flakes, in the subarachnoid space and ventricles, the latter being considerably dilated and the convolutions flattened. The choroid plexuses may appear normal, reddened, or oedematous.

The fluid contains leucocytes and a high percentage of proteids.

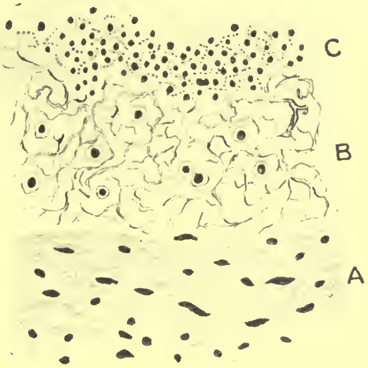

FIG. 185.—Plastic streptococcal infection of dura mater. Obj. $\frac{1}{8}$ in. A, Dura mater; B, plastic exudate; C, leucocytes and streptococci.

The *purulent* type is marked by a thick creamy exudate, much smaller in quantity than the serous, containing abundant leucocytes and often fibrin filaments and red corpuscles (Fig. 185). It may be distinctly localised, basic, or general. The ventricular contents are turbid, and the choroid plexuses matted with coagulated lymph which is seen as a sticky exudate on the surface of the hemispheres and dipping into the sulci.

Between these extremes, various degrees exist according to the intensity of the inflammation, its rapidity, and the nature of the infective organism.

As a rule the bacteria found in the fluid are practically the same as those found in the diseased antro-tympanic cavity when the communicating aperture is a large one, but the varieties are not so great. Sometimes only one or two varieties are present, especially when infection occurs along the internal auditory meatus from the labyrinth.

Although any pyogenic organism may be responsible for acute meningitis and has been demonstrated, there are several which the writers have found to be specially prevalent.

First and most frequent is a Gram – diplococcus having morphological and cultural characters of *diplococcus catarrhalis*. Next come *streptococci* (*brevis* and *longus*), *staphylococci* (*aureus*, *albus*, and *cereus*), *diplococcus meningitidis*, *bacillus pyocyaneus* and *pneumococcus*, in their order of frequency.

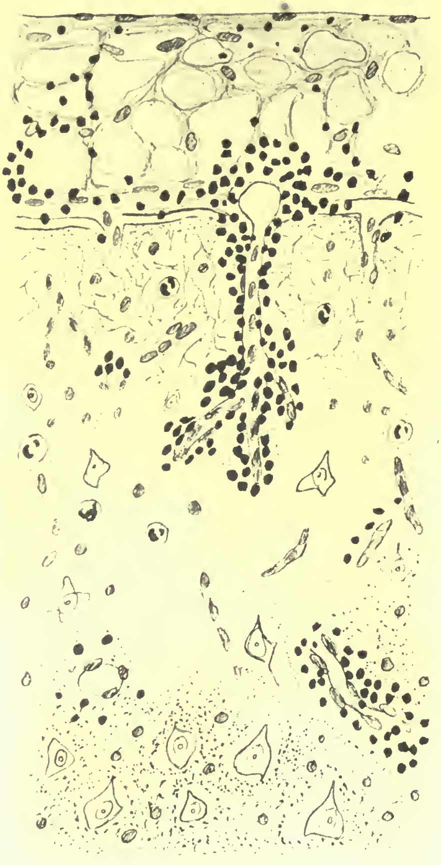

FIG. 186.—Meningo-encephalitis, from cortex of temporo-sphenoidal lobe adjacent to tegmen tympani. Obj. $\frac{1}{8}$ in.

In two cases associated with influenza, Pfeiffer's bacillus in company with small Gram – diplococci were present in large numbers.

In meningitis due to tuberculous disease of the ear, although tubercle bacilli are found in the fluid, other bacteria are invariably present. In one case the meninges showed no miliary deposit, although the cavity of an attendant temporo-sphenoidal abscess was lined with typical tuberculous elements.

When the posterior fossa is involved and the meningitis is chiefly basic, the spinal fluid is invariably involved, as shown by the examination by lumbar puncture. But when there is only limited involvement of the middle fossa the spinal fluid may afford little cytological evidence, but albumen will be present.

Symptoms.—The symptoms of a commencing meningitis are frequently vague and indefinite. This is to be explained from the fact that the meningeal infection is often, at the commencement at any rate, a local process, and also because it may be complicated with other intracranial lesions, *e.g.* abscess of the brain, sinus phlebitis, etc. The most pronounced and most constant symptom is headache, localised in the first instance to the same side as the aural lesion, but subsequently, and often rapidly, spreading over the whole head. It is frequently very intense over the frontal region, and gives rise to a feeling as if the head were about to burst. It is caused by the pressure of a gradually increasing exudate upon the surface of the dura, by a simultaneous increase in the amount of cerebro-spinal fluid, by oedema of the brain, or by sudden interference with the balance of pressure between the intraventricular and subarachnoid fluids owing to their channels of communication becoming blocked.

It is aggravated by any movement of the head and by extraneous noises. Accompanying it there is invariably marked intolerance to light (photophobia), the patient lying with the eyelids tightly closed and the head turned away from the light. In addition the patient is irritable and resents being spoken to or roused from the state of stupor into which he is gradually passing. As a rule he lies curled up in bed with his knees drawn up to his chin, or upon his back with his head extended.

Retraction of the abdominal parietes is also usual.

Delirium is exceedingly common, especially amongst children. In adults, in the early stages of the disease, rambling incoherent talking, shouting, moaning, or crying out is almost invariable.

Convulsions, limited at first to certain muscles or groups of muscles, finally becoming general, are frequent. At times they are of an epileptiform character. In a few cases trismus has been noted.

Rigidity of the muscles of the neck is common, so that the patient has great difficulty in moving the head forwards, backwards, or from side to side. This is more especially noticeable in cases of basal meningitis of the posterior fossa.

In advanced cases when the meningeal infection spreads downwards along the membranes of the cord, rigidity of the muscles of the back may be so pronounced as to produce a condition of opisthotonos. Spasmodic contraction of various other muscles, or groups of muscles, may also take place, and may be repeated several times during the day, *e.g.* contraction of the abdominal muscles. Rigidity of other muscles is also not uncommon. Thus Kernig has demonstrated one very important and frequent sign of meningitis, viz. an inability when the patient is sitting upon the edge of the bed with his legs hanging down, to straighten the lower leg on account of a strong contracture of the flexors of the knee. The test may be equally well applied when the patient is lying in bed. The thigh is first flexed at right angles to the trunk when it is now found impossible to extend the leg.

As the meningitis spreads over the motor areas of the cortex, and as the amount of exudation, and consequently of pressure, increases, paresis, and finally paralysis of the various muscles or groups of muscles implicated, supervenes.

Aphasia is comparatively rare.

Cutaneous hyperaesthesia is common, and erythematous and herpetic eruptions at times occur. The various skin reflexes are exaggerated, as are also the tendon reflexes.

Circulatory System.—In the early stages of the disease the pulse is comparatively slow and hard, but as the inflammatory process extends it becomes rapid and soft. The blood-pressure, which at first is high, gradually becomes lower and lower, and the pulse so soft as to be hardly perceptible. Vaso-motor paresis of the cutaneous blood-vessels is frequently met with. Thus when the finger-nail is sharply drawn across the skin a white line, which remains white for a prolonged period, is produced—*tache cérébrale.*

The temperature is always elevated. As the disease advances it ranges from 100° to 106° F. Shortly before the fatal issue it may attain to 107° or 108° F. It does not, however, show the frequent and severe oscillations so common in cases of sinus thrombosis, and is in very marked contrast to the normal or subnormal temperature of cases of intracranial abscess.

In cases when meningitis is complicated with sinus thrombosis or brain abscess, the temperature curve is erratic and varies with the predominance of the particular lesion or lesions present.

The vomit is rarely of the bilious type, but may be accompanied by severe retching.

In the early stages of the disease vertigo is not infrequent. Constipation is a marked symptom. As the disease approaches a fatal termination paralysis of the sphincters occurs, accompanied by involuntary evacuations. The abdominal wall becomes in-drawn and the patient presents a wasted appearance.

Involvement of various cranial nerves is common, especially in basilar meningitis. Thus paralysis of the third nerve, producing ptosis, and of the sixth, producing external strabismus, is not uncommon. Paresis or paralysis of the seventh leading to facial tremors or palsy and ultimately to disturbances in the conjunctivae is frequent, whilst paralysis of the eighth nerve is almost invariable in meningitis of the posterior fossa.

Optic neuritis or choked disc is fairly frequent, but is by no means a diagnostic symptom. Its occurrence is stated by certain observers to be very common, by others to be very rare. According to the writer's experience, it has been found present in 55 per cent of his cases.

Both pupils are, as a rule, contracted, equal in size, and react sluggishly. One may, however, be found contracted, the other dilated. Nystagmus, both horizontal and vertical, is not uncommon. The conjunctivae become gradually congested and puffy.

In certain cases many leading symptoms may be conspicuous by their absence. In all, however, headache, mental lethargy, and somnolence are present.

Diagnosis.—From what has been said above, an absolute diagnosis of meningitis is not always possible, although its existence may be suspected, the more so if an acute or chronic otitis media is likewise present.

The fact that the infection may be localised, or that it may be accompanied by other intra-cranial complications, suggests at once a ready explanation of the difficulties encountered in diagnosis.

The evidence afforded by lumbar puncture is of the greatest value. In severe cases the amount of cerebro-spinal fluid is greatly increased in quantity and flows out under high pressure. It presents an opaque, cloudy appearance, due to the presence of large numbers of polynuclear leucocytes. Lymphocytes are comparatively rarely found, but endothelial plates are frequently in evidence. Bacteria are also found at times, but may be entirely absent.

When meningitis is localised to the middle fossa, lumbar puncture may afford no evidence of its existence except the presence of albumen, but when situated in the posterior cranial fossa the evidence obtained by puncture is absolutely reliable.

Course of the Disease.—As a rule the course of the disease is rapid, death usually taking place in from seven to ten days. In acute fulminating cases a fatal issue may result within forty-eight hours.

Prognosis.—Until within the last few years the outcome of a case of otitic meningitis was looked upon as assuredly fatal. Latterly, however, various observers have recorded cases of recovery as the result of the elimination of the primary septic focus in the temporal bone accompanied by repeated spinal puncture, or as the result of multiple incisions and drainage of the subarachnoid space.

Cases of encapsulated and of acute progressive meningitis offer a field for the employment of surgical skill, and operation should not be neglected provided that the findings from a lumbar puncture, together with the clinical signs, afford reasonable evidence that the infective process has not become too general. In addition the employment of suitable antitoxins with or without previous surgical interference has done something to help to diminish the death-rate in such cases.

Although it is true that a peculiarly favourable combination of pathological conditions must be present to permit of a successful result, the encouraging fact remains that certain cases have been found to be amenable to suitable surgical interference, and therefore a distinct advance has been achieved in the treatment of this formerly invariably fatal complication. Every case, unless the patient is absolutely moribund, should be operated upon and the meninges freely drained.

The occurrence of herpetic eruptions along the branches of the trigeminal nerve should be regarded as of ill omen, indicating as it does extension of the original temporal bone disease to the apex of the pars petrosa and involvement of the Gasserian ganglion.

Treatment.—In the treatment of otitic meningitis the first essential is to tap the lumbar theca and to make a careful cytological and bacteriological examination of the cerebro-spinal fluid. When found to contain polymorphonuclear leucocytes and but few lymphocytes, the deduction is that the infection is acute. In the early, and at times in the late stages of the disease comparatively few bacteria are found, especially in cases of serous meningitis. When present they are always more or less intracellular. Clinically, streptococcal is more dangerous than either pneumococcal or staphylococcal meningitis.

Withdrawal of cerebrospinal fluid by lumbar puncture possesses a remedial as well as a diagnostic value by diminishing intra-cranial pressure and by relieving symptoms. The fluid should be withdrawn slowly, and the amount removed should be determined by the degree of intradural pressure. Generally the withdrawal of from 10 to 20 c.c. is sufficient at one time. Puncture should be repeated, however, should intra-cranial pressure increase as indicated by headache, slowing of the pulse, etc. The primary focus of disease within the temporal bone should be removed in cases following an acute otitis media by a complete exenteration of all infected mastoid cells and diseased bone; in those following chronic otitis media by the performance of the complete post-aural operation. Every vestige of infected bone should be removed and the whole cavity thoroughly disinfected.

When an extra-dural collection of pus is found all overhanging bone should be freely cut away, care being taken to avoid breaking down adhesions around the confines of the abscess cavity, adhesions which form a natural barrier against the spread of the infective process. The underlying dura is, as a rule, covered with granulations, in part necrotic, in part protective. Whether these granulations should be curetted or not is a matter upon which opinion differs. The writer's practice is to leave them severely alone after having provided free drainage and after having cleansed the surface with perhydrol solution and applied pure carbolic acid. When the infective process has reached the subdural space the line of treatment to be adopted depends upon whether the meningitis is serous or purulent, and upon whether there is ventricular distension or not.

To drain the sub-dural space a large area of bone should be removed. This is best accomplished by extending the original incision used to expose the mastoid process forwards towards the external angular process of the frontal bone, and, if necessary, backwards towards the occiput. The incision should divide everything down to the bone. The soft tissues are then retracted, and a piece of bone, at least two inches square, removed by means of trephine, gouge, and rongeur forceps immediately above the level of the zygoma, the opening being extended downwards so as to expose the roof of the middle ear and antrum.

The dura should then be opened either by a longitudinal or right-angled incision, or by the fashioning of a quadrilateral flap. Strips of gauze should be introduced under the margins of the dura and retained for drainage purposes. The performance of this decompression operation is, as a rule, sufficient to relieve urgent symptoms, and at times to effect a complete cure. The writer has operated upon 4 cases of serous meningitis according to the method indicated above and in each case with success. When symptoms point to involvement of the posterior cranial fossa it may be necessary to perform a similar decompression operation over the cerebellar area. The original mastoid incision is accordingly prolonged horizontally backwards towards the middle line and a flap consisting of skin and the underlying occipital muscles thrown down. The whole of the osseous tissue between the curved lines of the occipital bone should be removed so as to expose a large area of cerebellar dura. It is then incised and drained as already described in temporo-sphenoidal decompression. Cerebellar decompression may also be accomplished by opening the dura covering the posterior surface of the pars pyramidalis in the space between the lateral sinus and the internal auditory meatus, in other words by drainage of the subarachnoid "cisterna" (p. 416). In a case of acute serous meningitis recently under the writer's care this method of cerebellar decompression, in conjunction with temporo-sphenoidal decompression, was adopted with a satisfactory result, a preliminary cerebro-spinal puncture revealing a high grade of intra-dural pressure. This necessitates, however, the removal of a portion of the internal ear, but, considering so many cases of basal meningitis originate in the posterior fossa as the result of labyrinthine infection, the procedure is founded upon recognised surgical principles.

Instead of making the musculo-cutaneous flap already described, H. Cushing[1] recommends an "intermuscular" operation. The skin, subcutaneous tissue, and temporal fascia are first of all dissected up in the form of a flap. A perpendicular incision is then made through the substance of the temporal or occipital muscles and pericranium, and the underlying bone exposed by retracting their edges. The necessary amount of bone is then removed under cover of the muscle. The advantage claimed is that the risk of subsequent *hernia cerebri* is much diminished.

In addition to incisions at the site of infection, Friedrich advises counter-drainage through the spinal dura by the performance of a laminectomy.

Occasionally it may be necessary to drain the lateral ventricles. This is readily accomplished through the operation wound required for temporo-sphenoidal decompression, a knife or fine trocar being passed through the substance of the brain at a point 3 centimetres above the auditory meatus (Keen).

Dench[2] has recorded 2 cases of drainage of the fourth ventricle through the cerebellum, both, however, ending fatally. In 5 cases Krause performed successful punctures, the needle being entered at the angle formed by the dura at the junction of the cerebellum and medulla oblongata, and directed upwards and forwards in the sagittal plane at an angle of 45°, thus avoiding the important nuclei upon the floor of the cavity.

To maintain drainage once the ventricle has been opened a strip of gauze or a small silver tube should be inserted.

Unfortunately, the treatment of diffuse purulent meningitis has, so far, generally proved unsatisfactory. In the near future it may, however, be confidently expected that with the early removal of the primary focus of disease, extensive decompression operations, and the efficient maintenance of drainage, results of a more gratifying nature will be recorded.

The application of ice-bags, local depletion by the application of leeches, and the internal administration of calomel, saline draughts, and iodide of potassium are at times useful in combating symptoms. When the temperature is very high, tepid spinal sponging is useful.

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[1] *Surgery, Gynaecology, and Obstetrics*, vol. i., October 1909, No. 4.

[2] *American Journal Med. Science*, February 1901.

4. **Meningitis Serosa.**—In certain cases of temporal-bone disease, serous exudation takes place into the meshes of the pia mater and ventricles of the brain, as the result of toxic irritation. The amount exuded varies greatly, and depends to a large extent upon the virulence, extent, and duration of the existing local lesion. It may occur as the result of any infective lesion of the temporal bone. According to Jansen, however, it is peculiarly liable to result from labyrinthine suppuration, especially when the escape of pus from the infected internal ear is interfered with.

It is also met with in cases of extra-dural abscess and sinus phlebitis.

Symptoms.—The symptoms of serous meningitis are very similar to those of the purulent type although not so severe. The fact that a serous and not the purulent type of meningitis has existed is frequently only recognised as the result of the complete recovery of the patient.

The main symptoms are the existence of severe headache, frequently frontal, dizziness, vomiting of the cerebral type, an ataxic gait, and occasionally strabismus. When the amount of fluid exuded is very large, paresis or paralysis of certain groups of muscles, somnolence, and ultimately coma, may supervene.

The temperature is elevated, but never to such a degree as in purulent meningitis. As the intra-cranial pressure increases, both pulse and respirations become slower.

Course and Terminations.—Provided that the focal suppurative lesion to which the serous meningitis is due can be and is removed, recovery is likely to take place. On the other hand, the exudation, aseptic at first, may, during the course of the disease, become suddenly infected, resulting in the production of acute purulency with a rapidly fatal issue.

When the focal disease is not speedily removed a fatal issue is almost certain.

The prognosis is better in those cases in which the fluid, as drawn off by lumbar puncture or incision of the dura, is clear and free from leucocytes and bacteria.

Diagnosis.—An accurate diagnosis is very difficult. The existence of serous meningitis may, however, be inferred if, after the performance of a mastoid or labyrinthine operation, those symptoms indicative of increased intra-cranial pressure rapidly pass off, or if, during the course of the operation, the dura has been incised with an immediate discharge of a large quantity of serous fluid under pressure.

Jansen regards the existence of a fistula in the external semicircular canal as diagnostic of serous meningitis, and considers the presence of optic neuritis a confirmatory sign.

The evidence afforded by lumbar puncture, even if the fluid escapes in large quantity and under pressure, is not conclusive, as the amount and the degree of pressure is frequently increased in various intra-cranial lesions. Even in cases of purulent meningitis, especially when situated in the middle fossa and limited to the cortex, the cerebro-spinal fluid is at times perfectly clear and free from bacteria.

Treatment.—The treatment of serous meningitis consists in :—

1. The immediate removal of the focus of infection.
2. Repeated puncture of the spinal theca, or
3. Incision of the dura over the tegmen antri.

In cases where an extra-dural abscess is found, associated with what has clinically been diagnosed as serous meningitis, the dura should be at once incised and the sub-dural space drained.

In cases of associated labyrinthine suppuration any fistulous tract through the external semicircular canal should be enlarged, and if necessary inferior vestibulotomy or the complete "bridge" operation performed.

When high temperature exists, with marked oscillations, the sigmoid groove should be exposed and the sinus opened if necessary.

Lumbar Puncture.—To relieve the markedly increased intra-cranial pressure, the cause of the above-detailed symptoms, an amount of cerebro-spinal fluid varying with the severity of the case, but never exceeding 50 c.c. at one time, should be drawn off.

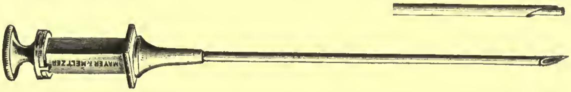

FIG. 187.—Trochar and cannula for puncture of the lumbar theca.

Normal cerebro-spinal fluid is a perfectly clear and transparent fluid, with a specific gravity of 1003-1004, and contains neither cellular elements nor fibrin. When, however, there is any inflammatory exudation into the meninges it will be seen to be cloudy, and upon standing to contain a deposit of fibrin. On microscopic examination the cloudiness will be found to be due to the presence of cellular elements and pyogenic bacteria.

An opalescent fluid with lymphocytes only is, as a rule, indicative of a chronic tuberculous meningitis.

In order to withdraw the fluid, a trochar (Fig. 187) from 7 to 10 centimetres in length and 1 millimetre in diameter is required, which should be carefully sterilised before use; also a receiver of a capacity of 6 to 20 c.c.

Lumbar puncture may be performed with the patient sitting astride a stool with head and body bent forwards, or lying upon the side in bed with the thighs well flexed upon the abdomen and the back well curved.

In young children it is advisable to give a general anaesthetic; in adults the skin in the immediate neighbourhood of the puncture should be anaesthetised with chloride of ethyl. The skin should be carefully cleansed with soap and water, and rubbed with turpentine and spirit immediately before the puncture is made.

A point midway between the spines of the third and fourth lumbar vertebrae, and about half an inch from the middle line should be selected as the point of puncture. To find this point a line should be drawn between the top of the iliac crests, when it will be found to cross the interspace between the third and fourth lumbar spines. In adults a point half an inch to the right or left of the middle line should be selected, and the trochar driven through the skin and muscles of the back slightly upward and towards the middle line, between the laminae of the third and fourth lumbar vertebrae, until it reaches and enters the spinal canal. Should fluid not escape on removing the trochar the cannula may be moved slightly upwards and downwards but never laterally. Under normal pressure fluid escapes at the rate of 60 drops per minute; if it be moderately high the flow is in a constant stream, but if very high it will spurt a considerable distance. Such evidence of pressure is the best guide as to the amount to be withdrawn. When the pressure is moderate 10 to 20 c.c. should be the limit. In children it is advisable to pass the trochar, the head and body being bent forwards, between the third and fourth lumbar spines and exactly in the middle line where there is ample space.

The amount of fluid drawn off at first should not exceed 10 c.c. otherwise severe headache, nausea and at times vertigo, are complained of.

The fluid may sometimes be quite clear, only a few leucocytes being found on centrifuging. Evidence of inflammation is, however, afforded by testing for proteids with a solution of salicyl-sulphonic acid or by its spontaneous coagulation. Such may happen when the meningitis is confined to the middle fossa or vertex (*vide* p. 395 for further description of cerebro-spinal fluid).

As the result of injury to one or other of the nerve bundles in the cauda equina, pain in the leg is afterwards complained of.

Fatal results have been recorded as the direct result of lumbar puncture, probably due to a too rapid and too generous removal of fluid.

After the withdrawal of the cannula the puncture in the skin should be immediately sealed up with a collodion dressing.

5. **Epidemic Cerebro-Spinal Meningitis.**—In view of the important aural lesions associated with this disease, a few details are demanded.

Cerebro-spinal meningitis, known also as "spotted fever," is characterised by headache, fever, vomiting, unconsciousness, convulsions, rigidity of cervical muscles, and an irregular eruption of purpuric spots.

The aural symptoms appear towards the end of the first, or beginning of the second week. They occur in a very large percentage of those attacked, although varying considerably with each particular epidemic. The deafness both for speech and tones is bilateral. That the vestibular apparatus is involved is seen by the staggering gait. This, however, in 50 per cent of cases, disappears in adults after twelve months' duration, but in children it lasts somewhat longer, and may possibly be cerebellar titubation. The deafness, however, is sudden, complete, and permanent, since it is due to complete destruction of the cochlear elements.

Impairment of other senses is often seen, such as vision, smell and taste, but these generally recover during convalescence.

Early diagnosis by lumbar puncture is readily established, cytologically and bacteriologically. Besides the characteristic excess of polymorphic leucocytes, a Gram – diplococcus is seen. Too much importance has been attached to its intracellular occurrence, which is entirely dependent, as with other bacteria, upon the existing phagocytic content. It is generally known as the *diplococcus meningitidis intracellularis* of Weichselbaum, although some authorities maintain that the diplococcus of the epidemic type differs from Weichselbaum's. As the question is still undecided, it will be sufficient to give the general characters by which it can be recognised.

It is a small Gram – diplococcus without a capsule when seen in the cerebro-spinal fluid, but in cultures it may assume a large size. In shape it is spheroidal or facetted, with a special affinity for carbol thionin; its intracellular occurrence is not peculiar. It grows best on nasgar at 37° C. as smooth, discrete, transparent circular discs (the only Gram – diplococcus to do so). It gives an acid reaction with all carbohydrate media, except sucrose.

Pathology.—From the symptoms it would appear that the changes at first were equally cerebellar and labyrinthine, but post-mortem evidence abundantly proves the striking involvement of the latter organ.

The channel of infection is probably from the meninges to the labyrinth by the perineural and perivascular sheaths of the seventh and eighth nerves and their vessels, since pus may readily be traced along them through the internal auditory meatus to the pars cribrosa. Infection may also be conveyed by the *aqueductus cochleae* and *vestibuli*, both of which have been found crowded with leucocytes, lymphocytes, and bacteria. Within a few days the whole of the membranous labyrinth has lost its identity, vestibule, semicircular canals, cochlear canal, epithelium, and other structures being completely hidden by pus products. This may be followed either by granular liquefaction due to tryptic action, or by sclerotic changes as is shown by examination in after years, with complete or partial obliteration of the labyrinthine cavity; or it may happen that granulation tissue is formed.

Both cochlear and vestibular nerves undergo subsequent atrophy, and sometimes even the facial may be so affected.

In 15 cases of labyrinthine infection, Goerke has shown that in 11 it could be traced along the auditory nerve, in 3 through the aqueductus cochleae, and in 1 through the aqueductus vestibuli.

Necropsy will often show plastic exudate along the auditory and facial trunks, with cloudy swelling and leucocytic infiltration of the choroid plexuses.

The outlook with regard to hearing is almost hopeless, but so far as equilibrium disturbances are concerned, they generally disappear.

Treatment.—Lumbar puncture is not only the most direct means of diagnosis, but it is also one of the best therapeutic measures. Occasional withdrawal of 10 to 15 c.c. of cerebro-spinal fluid affords relief to symptoms, and in conjunction with the injection of the specific serum, has materially reduced the mortality. Wassermann's serum is very popular in Germany. In France Roux makes a serum by inoculating horses with the living coccus. In the very early stages of the disease, Leiter's cold-coil apparatus should be applied over the mastoid process. In order to endeavour to promote absorption of the exudate after the meningitis has run its course, iodide of potassium in 15-grain doses may be given, or subcutaneous injections of nitrate of pilocarpine made.

CHAPTER XXX

ABSCESS OF THE BRAIN

Brain Abscess.—Brain abscesses of otitic origin occur most frequently in the temporo-sphenoidal and cerebellar lobes, more rarely in the frontal and occipital hemispheres. As a rule only one abscess is present, although cases have been recorded where more than one collection of pus has been found. At times one abscess may be situated in the temporo-sphenoidal lobe, the other in the cerebellum. In pyaemic conditions, secondary to purulent otitis media, several abscesses may be discovered scattered throughout the substance of the brain. As a rule an intra-cranial abscess of otitic origin develops in close proximity to the original septic lesion within the temporal bone. At times, as the result of necrosis of the cerebral substance, the abscess may be in actual contact with the infected meninges, at other times a layer of healthy brain substance intervenes (Fig. 188).

Temporo-sphenoidal abscesses develop, as a rule, in closer relation to co-existing disease within the temporal bone than do cerebellar, but they are often more deeply situated in the brain substance. Occasionally an abscess develops upon the side opposite to that of the original ear disease (pyaemic abscess).

Intra-cranial abscesses of otitic origin are most frequently met with between the ages of ten and thirty, and occur in males about three times as frequently as in females. They are more frequent upon the left than upon the right side.

In a case of temporo-sphenoidal abscess successfully operated upon by the writer, the patient's age, a female, was seventy-nine, and the duration of the accompanying purulent middle-ear disease forty years.

Intra-cranial abscesses occur as the result of chronic much more frequently than as the outcome of acute purulent otitis media, and are said by most authorities to be situated more frequently in the cerebrum than in the cerebellum.

A brain abscess may be complicated by the presence of infective meningitis, thrombo-phlebitis, or general pyaemia. Occasionally an intra-cranial collection of pus is found as the result of suppurative disease of one or other of the nasal accessory sinuses concurrently with chronic purulent otitis media.

When the abscess is due to middle-ear suppuration it is usually situated in the region of the tegmen tympani or antri, but when to purulent labyrinthitis or caries of the pars petrosa in the corresponding cerebellar lobe.

Pathology.—When of aural origin the abscess is situated on the side which corresponds with the diseased ear, but as it may happen that disease may occur on both sides, at one and the same time, some difficulty may therefore occur in its exact localisation. Such happened in a case reported by Stuart Low in which necropsy revealed an additional abscess in the temporo-sphenoidal lobe opposite to that which was evacuated by operation. There was disease in both ears, but it was quiescent in the ear not operated upon.[1] Further, it may occur in both cerebrum and cerebellum at the same time.[2]

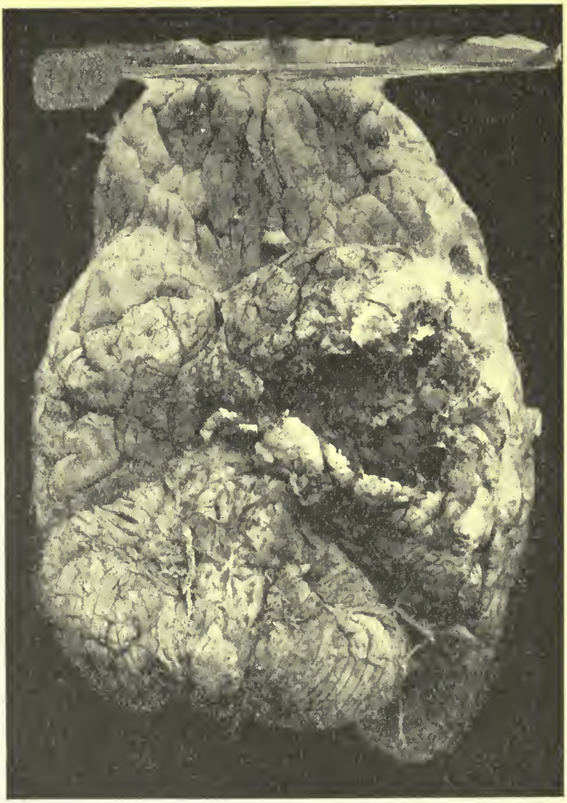

FIG. 188.—Large temporo-sphenoidal abscess (from the Pathological Museum of the Victoria University of Manchester).

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[1] *Medical Reports, Central London Throat and Ear Hospital*, vol. i. (1908), p. 61.

[2] Whitehead, *Journal of Laryngology*, vol. vii. p. 23.

It is more common in the cerebrum than in the cerebellum, the writer's figures showing the proportion of 14 to 8. Some observers, however, report a slight excess in favour of the cerebellum.[1]

With regard to the cerebral hemisphere the abscess is usually in the temporo-sphenoidal lobe, deeply situated in the white substance and surrounded by an apparently healthy cortex (Fig. 189). This, however, may be oedematous, or stained deeply grey or green, or bruised in appearance.

Most frequently a single brain abscess is found, but occasionally two or three have been discovered.

A cerebral abscess is usually sharply circumscribed, but may extend to the descending horn of the lateral ventricle or into the occipital lobe.

A cerebellar abscess, on the other hand, is usually very superficial, the outer wall being thin and necrotic, so that its contents readily escape on removing the brain. It is always situated in the lateral lobe, but may extend to the fourth ventricle (Fig. 190).

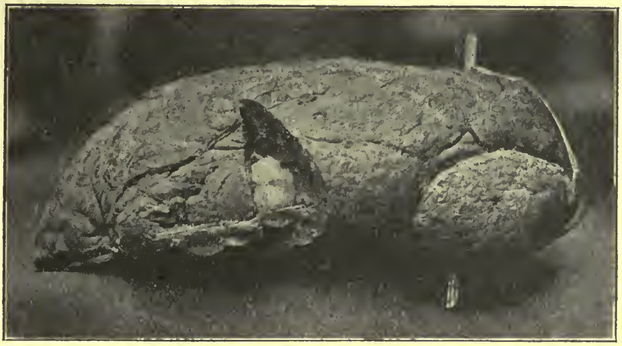

FIG. 189.—Temporo-sphenoidal abscess, showing depth of cavity which contains wool. The excised cortex was normal.

Instead of a true abscess being formed, a small patch of grey or discoloured cortex may be seen corresponding with the area of the bone lesion. This constitutes a local encephalitis, but would doubtless have later developed into an abscess (Fig. 191). In one such case the patient died from meningitis, in another there was no meningitis, but death was due to profound toxaemia caused by streptothrix.

Wall and Contents of the Abscess.—The walls and the contents of a brain abscess will obviously vary with the rate of formation and the nature of the infection. When due entirely to tubercle the abscess is generally deeply situated and slow in its development, in marked contrast with that form primarily due to a pyogenic infection. A slowly forming abscess presents sharply defined and thickened walls (encapsulated), not collapsing on evacuation. It may even possess a dense fibrous sheath or capsule composed of fibroblasts with a few giant and plasma cells showing low vascularity with a small outer zone of lymphocytic infiltration. This capsule is probably formed from granulation tissue, and is said to be formed in about four weeks (Ziegler). Tubercle bacilli are not always seen. The more acute form, however, shows less sign of encapsulation, the wall being softer, granular, with numerous endothelial and plasma cells, perhaps giant cells and lymphocytes, and in this case tubercle bacilli will be more easily found together with pyogenic or other bacteria due to supplemental infection. In neither case can the abscess be considered acute, since such structures are not formed within a few days. The walls of an acute abscess are always soft and collapsible, and are formed by a well-defined layer of necrotic brain substance, which microscopically may be described as consisting of three zones.

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[1] Whitehead, *Journal of Laryngology*, vol. vii. p. 23.

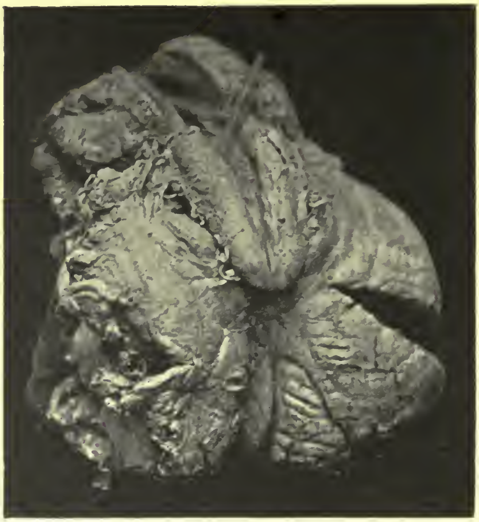
FIG. 190.—Cerebellum. Abscess in right lobe communicating with 4th ventricle, through which a probe is passed. Gap in left lobe only exploratory.

1. An external or peripheral, which consists of medullated nerve fibres, ganglion cells, dendrons and glia cells, with a few wandering polymorpho-nuclear leucocytes specially noticeable in the perineural and peri-vascular channels, which, with the blood-vessels, are well marked.

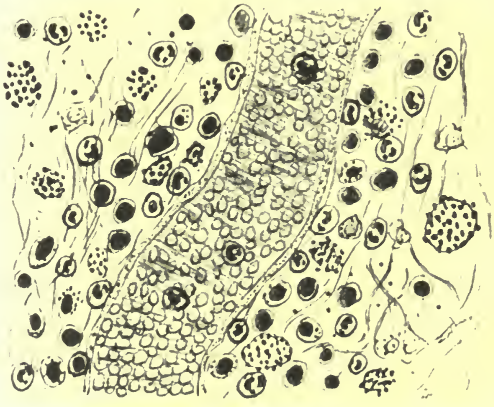
FIG. 191.—Acute encephalitis, showing exudate of leucocytes and lymphocytes into the peri-vascular lymph space. Obj. $\frac{1}{12}$ in.

2. In the intermediate zone the leucocytes are much more numerous, and the ganglion and glia cells with the nerve fibres swollen, vacuolated, granular, and "breaking down."

There is considerable distension of the blood-vessels and peri-vascular channels, which are choked by leucocytes and bacteria.

3. The innermost zone consists almost entirely of amorphous granules, mingled with deeply staining spherical and irregularly shaped masses of chromatin, evidently the nuclear relics of nerve cells, glia cells, and leucocytes, together with bacteria. Myelin spheres, chromasome relics, with the remains of ganglia containing fat granules, are occasionally seen.

Should the abscess be of slower formation the wall will be formed by granulation tissue composed of lymphocytes, endothelial cells, and primitive capillaries.

Contents.—The contents of an abscess vary according to the rate of its formation and the nature of the infection. The exudate may be a thin opaque fluid like "curds and whey," or creamy, coffee-coloured, rusty, red, grey, or green. It is frequently very foetid, and contains similar bacteria to those existing in the antro-tympanic cavity.

The matrix consists of albumin and cell globulin in solution, holding an emulsion of amorphous granules which consists of fatty and myelin substances. Some of these granules select basic stains, stain deeply, and are doubtless nuclear relics. Myelin and paranuclear spheres are more readily stained with fuchsin, eosin, and pyronin. Crystals of fatty acids (cholesterin) are rare and are only seen in old abscesses. Unless the exudate is comparatively recent, cells are generally few in number and show signs of degeneration. Leucocytes of the poly-morphonuclear and the mononuclear variety, especially the latter, are few in old abscesses, but numerous in recent formations, their cytoplasm and nuclei exhibiting the characteristic variations of degeneration and tryptolysis. Lymphocytes are not numerous, since granulation tissue is uncommon. The remains of ganglion cells are identified by the possession of large nuclei containing a well-marked paranucleus. Endothelial elements are sometimes seen, and may be recognised by their large oval and faintly staining nuclei. Glia cells have a somewhat smaller nucleus than ganglion cells, but they too are not very numerous, and are recognised by their pale nuclei and irregular or branching outlines, which also distinguishes them from lymphocytes and endothelium. Myelin masses or spheres are readily distinguished from chromatin or nuclear relics by their staining reactions as already mentioned. They are very numerous in all abscesses, but are smaller and granular in old ones. They may also, like chromatin spheres, be seen inside endothelial cells and leucocytes.

Fatty acid crystals in "sheaves" and cholesterin crystals as flat rhombic plates are best seen in films which have not been washed in alcohol.

Degenerated ganglia are often only represented by large, round, or oval nuclei containing paranuclei, surrounded by a more or less scanty ragged zone of cytoplasm containing refractile fatty bodies.

As pointed out by Wright and Opie such changes indicate the production of tryptic ferments by disintegrating leucocytes which have the power of dissolving all cells and tissues. These somewhat lengthy histological details are given with the object of differentiating between old or recent abscesses, a question which is often put but can sometimes only be fully established by the aid of the microscope. Still it is important to bear in mind that a very old abscess may be the seat of a supplemental and active infection as, for instance, in tuberculosis.

Bacteria.—In chronic cases the bacteria of a brain abscess are practically the same as those found in the infecting antro-tympanic cavity. In acute cases they are usually fewer in number and variety and confined to the pyogenic group.

When the abscess is foetid two distinct types of micro-organisms are found, viz. spirochaetae and acid-fast bacilli which have already been discussed in connection with aural discharges. They are often found in large numbers, and are almost invariably associated with prolonged decomposition and foetor.

Streptothrices of the Gram + type and acid-fast were seen in one of our cases in the form of felted masses. Occurring with the *bacillus proteus vulgaris* and a Gram + diplococcus they were the predominant micro-organisms and were justifiably considered as the exciting pyogenic factors.

In acute abscesses the following were the chief bacteria:—

Staphylococci (albus and aureus).
Streptococci (brevis and longus).
Diplococci—including the Meningococcus.
Bacillus proteus vulgaris.
Bacillus pyocyaneus.

Tubercle bacilli are not easily found except in cases of tuberculous meningitis; old tuberculomata of the brain being, as elsewhere, remarkably free from them. With the spirochaetae, fusiform bacilli (*Bacillus hastilis*) were invariably present. A small bacillus resembling Pfeiffer's occurred in one acute abscess. In two cases no bacteria could be discovered at all, either in films or by cultivation.

Foetor.—The offensive odour of most brain abscesses is a well-known phenomenon, and is of great diagnostic significance when observed to persist after a radical mastoid operation and when symptoms are persistent.

It varies considerably in character, and has been compared with rotten fish, rotten cheese, smegma, faeces, etc. Although it often strikingly resembles that of the ear contents, there is undoubtedly a foetor characteristic of decomposing brain-matter, probably derived from the splitting up of lecithin in the presence of different putrefactive bacteria, notably *bacillus proteus vulgaris*, *bacillus butyricus*, and *bacillus coli communis*.

Spirochaetae are invariably associated with a foetor familiar to aurists and rhinologists, while acid-fast bacilli are attended by the peculiar odour of butyric acid. Doubtless *bacillus pyogenes foetidus* is also responsible, since it is sometimes found in old abscesses.

Cerebro-Spinal Fluid.—As lumbar puncture is now held to be of such diagnostic importance the characteristics of the fluid require careful consideration. It is only in a very small percentage of cases that the results are entirely negative. Such occurred in one case when the abscess was small, and situated deeply in the temporo-sphenoidal lobe without any meningitis whatever. Such an instance, however, is very rare. In two instances of a similar kind cytological and bacteriological evidence was also wanting in the fluid, but testing for cell globulin and albumin afforded positive evidence in perfectly clear specimens of the fluid.

But as basic meningitis is practically always present in cerebellar abscess the evidence must be taken as strongly presumptive when supported by clinical facts.

It would perhaps be too much to say that the early appearance of cells in the fluid points more to a cerebellar than to a cerebral site of the abscess, still it is an index which should not be disregarded. The fluid may be apparently clear, yet on standing or centrifugalising cells may be found in large numbers. It should always be tested for globulin and albumin by mixing equal parts of the fluid and a saturated solution of sodium sulphate and boiling, or with a few drops of salicyl-sulphonic acid. An opacity will at once appear if either are present. Another method (Nonne's)[1] is to mix it with an excess of a saturated solution of ammonium acetate, and allow it to stand for ten minutes, when a degree of opacity is said to follow which varies with the amount of globulin present.

Spontaneous coagulation may also take place, but this only when meningitis is present. The fluid may be slightly opalescent, turbid, opaque, straw-coloured, rusty, or even distinctly sanguineous. In highly purulent states minute flakes even may be seen.

The chief cells found are polymorphonuclear leucocytes. The mononuclear are rarely numerous unless active suppuration is going on.

Lymphocytes are rare in acute changes, but may be well marked in tuberculous cases, or when granulations are present in the meninges covering the temporal bone.

Large endothelial cells, recognised by their pale oval nuclei, are often seen. More rarely the short cubical epithelium from the choroid plexuses appears with eccentrically situated nuclei, strongly suggestive of ventricular complication.

On the whole, leucocytes are indicative of an acute, while lymphocytes in excess point to a chronic process. The more sharply defined the cell the more recent the exudation, while signs of cytoplasmic cloudiness with granularity and nuclear fragmentation or "clumping" (pyknosis) may be considered presumptive evidence of older changes.

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[1] *Münch. med. Woch.*, October 1907.

Bacteria are not present in every specimen of fluid obtained by lumbar puncture, but a careful search will generally disclose one or two enclosed within leucocytes. When very numerous, as in otitic meningitis, they will be extra-cellular as well. They are specially numerous both in number and variety in basic meningitis and cerebellar abscess due to aural infection. The commonest forms are diplococci (Gram –), but the Gram + form (*pneumococcus*) has occurred in several of our cases.

Streptococci and *staphylococci* come next in frequency, followed by *bacillus proteus vulgaris*, *bacillus coli communis*, and *diplobacillus* of Friedlander. In 1 case *spirochaetae*, *bacillus fusiformis*, *bacillus coli communis*, *bacillus proteus vulgaris*, and *torulae* were present in large numbers.

We have not seen tubercle bacilli in the lumbar fluid from brain abscess cases.

Haematology.—While blood examination affords valuable and important evidence of a deep suppurative process, it should only be considered suggestive or supplemental to clinical signs when utilised for the diagnosis of a cerebral abscess, especially owing to the frequent coexistence of sinus phlebitis, sub-dural suppuration, etc. The leucocyte count may be high or low in brain abscesses, but a slight leucocytosis is generally present in cerebral complications. Marked increase, however, following a radical mastoid is very significant of abscess formation, especially when it reaches 20,000 per c.m.m.

In some cases of brain abscess there is an actual leucopenia, the leucocytes falling as low as 2500. Such a condition if attended by serious clinical signs affords a bad prognosis (Ballance).

The blood-counts in our cases have on the whole indicated a moderate degree of leucocytosis, the highest being 30,000 per c.m.m.

A *differential* count in acute abscesses shows a distinct increase of the polymorphonuclear type, while in chronic cases the mononuclear may constitute 25 per cent of the leucocytes. Such a proportion of the mononuclear leucocytes after evacuation of the abscess has in our experience proved an important and serious indication, recovery being always associated with a relative rise in the proportion of polynuclear cells. In chronic abscesses iodinophiles and sudanophiles may be found.

Bacteria in the blood are generally difficult to find in cases of brain abscess. An occasional phagocyte may be seen in acute cases. When pyo-phlebitis is present they are, however, more readily demonstrated.

Meninges and Ventricles.—In most cases of acute brain abscess meningitis is present in varying degree and extent, yet examples are recorded,[1] and have been seen by us, in which both lumbar puncture and necropsy pointed to its absence. In each instance the temporosphenoidal lobe was the seat of abscess.

The meningitis may be serous or purulent in type, and more frequently basic in distribution.

The ventricles are usually greatly distended, the choroid plexuses showing marked congestion, and being covered with coagulated lymph, or even attached to the walls of the ventricle by adhesive inflammation (Fig. 192).

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[1] Whitehead, *Trans. Otol. Soc.* vi. 15 ; Walker, *ibid.* vii. 48.

Granulation tissue inside the dura mater is usually rare, but may often be seen on its outer aspect at the seat of infection. This will account for the lymphocytes when present in the fluid from a lumbar puncture.

Channels of Infection.—While the source of infection in most brain abscesses may be traced macroscopically to the diseased temporal bone, such a link may not be so clear in those deeply seated in the substance of the temporo-sphenoidal lobe, especially when separated from the temporal bone by an apparently thick zone of healthy-looking brain substance and intact meninges.

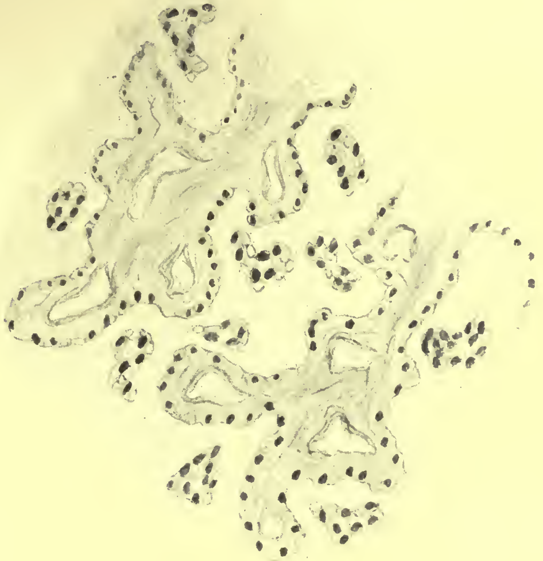

FIG. 192.—Choroid plexus from a case of serous meningitis. Obj. $\frac{1}{6}$ in.

Infection may have been conveyed by the peri-vascular lymph spaces of the meningeal vessels which penetrate deeply into the brain substance, or may have originated as the result of septic thrombi or emboli from the basilar or internal carotid supply. A latent abscess may originate in an old caseating tuberculoma which becomes secondarily infected by pyogenic bacteria from the ear.

That the infection is more likely direct from the ear than indirectly through the general blood stream is shown by the striking similarity between the micro-organisms in the abscess and those in the antro-tympanic cavity.

Intra-cranial infection from the middle ear may be conveyed through the following channels:—

Perforation of the sigmoid groove.
Perforation through petro-squamosal suture.
Perforation through tegmen antri and tympani.
Perforation through the "triangular area."
By the facial nerve sheath.
By the structures contained in the internal auditory meatus.
Aqueductus vestibuli (*ductus endolymphaticus*).
Aqueductus cochleae (*ductus perilymphaticus*).

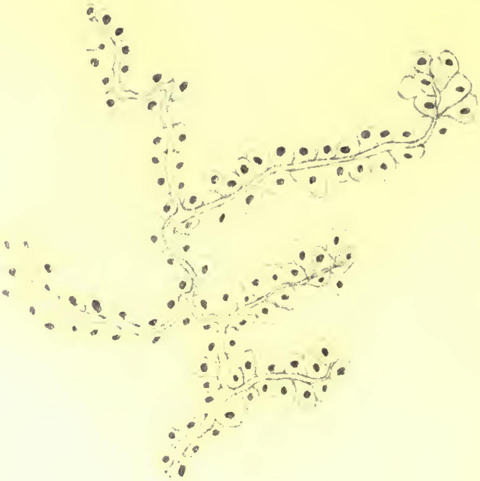

FIG. 193.—Choroid plexus (serous meningitis). Obj. ½ in.

The commonest fissures in the temporal bone which occurred in our necropsies were found in the—

Sigmoid groove.
Petro-squamosal suture.
Tegmen antri and tympani.

The "triangular area," bounded above by the superior petrosal sinus, behind by the sigmoid groove, in front by the posterior semicircular canal, described by Whitehead[1] as involved in 9 out of 23 cerebellar abscesses, we found involved in one instance only.

In one case of cerebellar abscess the intra-cranial aspect of the temporal bone was normal and the labyrinth was unaffected, but pus could be traced along the facial nerve in the internal auditory meatus and its canal to the diseased tympanum.

In two instances the labyrinth was the seat of infection, as was traced in the peri-neural and peri-vascular sheaths of the structures in the internal auditory meatus.

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[1] *Trans. Otol. Soc.* vol. vii.

In temporo-sphenoidal abscesses the tegmen antri and petro-squamosal suture were the most frequent sites of perforation (Fig. 195), while the sigmoid groove was involved in many of the cerebellar cases (Figs. 207 and 209).

Diagnosis.—The diagnosis of brain abscess is at all times a matter of difficulty and frequently of great uncertainty. Two main questions present themselves to the clinician: (1) Is an intra-cranial abscess present? and (2) if present what is its exact location?

A critical analysis of the various symptoms will, as a rule, enable the first question to be answered, but a definite reply to the second is, from the absence in many cases of focal symptoms, almost impossible. In addition a brain abscess is frequently complicated with some other lesion, *e.g.* infective meningitis, thrombo-phlebitis, etc., whilst in children symptoms practically identical with those due to intra-cranial pressure result from attacks of otitis media purulenta.

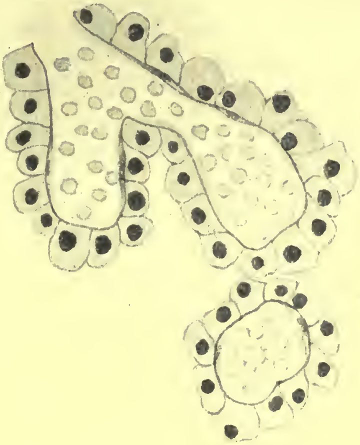

FIG. 194.—Choroid plexus (serous meningitis). Obj. $\frac{1}{8}$ in.

In the late stages of the disease the symptom-complex is so similar to that presented by certain other intra-cranial lesions of otitic origin that an accurate diagnosis is a matter of the greatest difficulty.

Clinically a brain abscess presents four stages :—

1. The *initial* stage of its formation.
2. The *latent* stage, during which period symptoms are both vague and indefinite.
3. The *manifest* stage, when symptoms are well marked.
4. The stage of *termination*, in which coma is the principal symptom.

When localising symptoms referable to the involvement of certain definite areas of cerebral tissue are present, such as sensory aphasia, paralysis of the face, arm, or leg centres, especially if accompanied by pain upon percussion, and by an increase of superficial temperature over the respective cortical areas, the diagnosis of an intra-cranial abscess is almost certain.

Various symptoms, *e.g.* "pressure" symptoms, are common to all intra-cranial abscesses, others have a differentiating value and indicate more or less approximately the site of the lesion.

Such pressure symptoms as headache, nausea and vomiting, vertigo and mental hebetude, slow pulse, subnormal temperature, choked disc or optic neuritis are common to cerebral and cerebellar abscesses. Certain other symptoms have a localising value of varying importance. Thus an abscess involving directly or indirectly the first temporal convolution upon the left side is accompanied by sensory aphasia, inability to identify objects, crossed deafness and anosmia; an abscess in the region of the fissure of Rolando by epileptiform convulsions and motor paralysis affecting the face, arm, or leg upon the opposite side of the body, while if involving the internal capsule by motor and sensory hemiplegia affecting the opposite side of the body.

In those cases where vertigo, nystagmus, constant yawning, rigidity of the muscles of the neck, and severe pain over the occipital region are predominant, the inference that the cerebellum is involved is warranted.

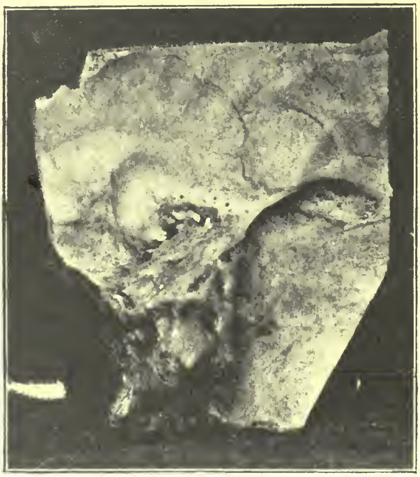

FIG. 195.—Perforation through tegmen antri and petro-squamosal suture (case of temporo-sphenoidal abscess).

Owing, however, to the fact that uncomplicated intra-cranial abscesses are the exception rather than the rule, careful and detailed study of any particular case, combined with ripe clinical experience, is necessary before a definite diagnosis can be made.

Temporo-sphenoidal Abscess.—*Symptoms.*—The most constant and the most distressing symptom is pain, which at first is slight and localised to the affected side of the head, but gradually becomes more severe and constant as the abscess and consequently the intra-cranial pressure increases. It is, as a rule, a continuous dull, heavy ache, although exacerbations are not uncommon, especially when any sudden increase in the size of the abscess takes place. Throughout the whole of the illness it remains as a prominent symptom. In several of the writer's cases where a fistulous tract has been established between the abscess cavity and the middle ear, and when consequently there is not the same degree of intra-cranial tension, comparatively little pain has been complained of. Even during the patient's delirium the cry of an agonising head pain is not infrequent. Although at times limited to the neighbourhood of the affected ear it is prone to become diffuse, and may be complained of as being most intense in the frontal or occipital regions. As a symptom it has unfortunately practically no localising value, except in those cases where the abscess happens to be situated superficially and under portions of the skull where the bone is comparatively thin. Under such circumstances percussion may elicit a sufficient amount of topical pain or tenderness to be of localising value. Certain authors (MacEwen) maintain that the percussion note upon the affected side of the head in the region of the suspected abscess cavity is higher than that over other portions of the skull-cap. The writer has carefully investigated this point in several of his cases, but has invariably failed to be able to draw any definite conclusions as to its clinical value.

Although pain is one of the earliest symptoms indicative of intra-cerebral suppuration, it must not be assumed that it accurately marks the commencement of all abscesses, or that it is present during the whole period of their formation. This is the more likely in those of the encapsulated, latent, and tuberculous type, since careful investigation, clinical and pathological, serves to show that characteristic symptoms were entirely absent during what must have been the earlier period of development. The complete isolation of the deep abscess from the otitic source of infection, together with an apparently healthy state of the intervening meninges and brain substance, coupled with our knowledge of the almost painless course of chronic otitic tuberculosis, strongly supports such a view. The more painful period is doubtless that of true or active suppuration rather than that of passive or slow caseation. The involvement of the dura mater is far more painful than that of the brain substance.

One must therefore not always accept the onset of pain as coinciding with the actual origin of a chronic cerebral abscess, although it is much more likely to be so in the case of an acute abscess, when intra-cranial pressure and meningeal irritation are more pronounced.

Attacks of sudden and uncontrollable vomiting are common in cases of brain abscess, just as in many other intra-cranial lesions. The attacks come on quite independently of the taking of food (cerebral vomiting), but are occasionally of a bilious type. They may be repeated several times during the twenty-four hours, and are occasionally so frequent as to cause great exhaustion.

In the early stages of acute brain abscess formation, and in those cases of chronic or latent abscess which become the seat of a supplemental infection, the temperature is elevated, but as the disease advances, and as intra-cranial pressure increases, it falls to normal or subnormal, and may remain so during the remainder of the illness, except when a sudden increase in the size of the abscess takes place, or when it bursts into the subdural space, in which case it suddenly rises to several points above normal. In cases where a brain abscess is complicated with meningitis or thrombo-phlebitis the temperature curve may show numerous oscillations dependent upon the predominance of the one or the other lesion. In uncomplicated brain abscesses, however, especially when of large size, the temperature remains, as a rule, normal or subnormal. In its initial stages a brain abscess may be ushered in by a rigor or series of rigors, in which case the temperature is elevated and shows more numerous oscillations.

According to Broca there is an elevation of the superficial temperature over the affected side of the skull.

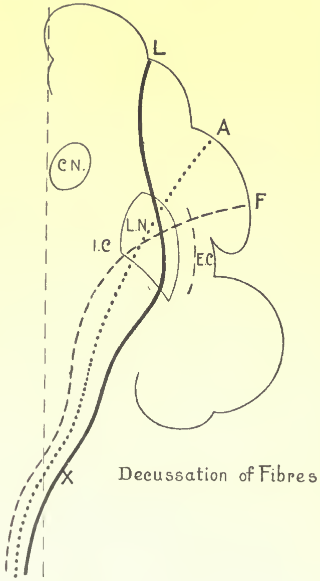

FIG. 196.—F, Face centre; A, arm centre; L, leg centre; LN, lenticular nucleus; CN, caudate nucleus; EC, external capsule; IC, internal capsule.

Accompanying the normal or subnormal temperature of a brain abscess the pulse will be found to be slow, full, and strong. As the abscess increases in size it becomes gradually slower and slower, often not attaining more than from 40 to 50 beats per minute. A still more striking feature is often seen in a marked disproportion between the pulse and respiration rate.

When an abscess is complicated with meningitis or thrombophlebitis the pulse-rate may remain slow, even although the temperature is high. In several cases of brain abscess complicated by meningitis seen by the writer there existed a very marked discrepancy between the ratio of the temperature to the pulse-rate, the former being considerably elevated, while the latter remained persistently slow. As the case approaches a fatal termination the pulse becomes very rapid and weak, the respiratory rhythm being strikingly disproportionate.

In a few cases of brain abscess Politzer has noted marked hyperaesthesia of the scalp in the occipital region.

As the disease advances the patient becomes more and more drowsy, so much so that there is at times considerable difficulty in rousing him from the state of mental lethargy into which he has passed. If roused and asked a question, an appreciable interval of time may elapse before any reply is given. The reply when forthcoming, uttered slowly and deliberately, is coherent and probably perfectly accurate, showing that the question has been fully understood. This condition of slow cerebration or mental hebetude is characteristic of brain abscess cases, and may almost be considered a pathognomonic symptom. Somnolence may be so marked that the patient, if roused to take food or to answer a question, may fall asleep again before food can be given or before he has answered the question. Gradually, as the fatal issue approaches, a profound state of coma is attained from which the patient cannot be aroused.

When the abscess is of large size, or so situated as to exert direct pressure upon the motor areas of the cortex, or upon the motor fibres passing through the internal capsule, paresis or paralysis of various muscles or groups of muscles on the opposite side of the body ensues, in exceptional cases complete hemiplegia developing. The accompanying schema (Fig. 196), representing a vertical section of the temporo-sphenoidal lobe, shows the course of the motor fibres from the cortex to the periphery and their relative position in the internal capsule, and is of value in explaining the occurrence of motor paralysis when met with in cases of temporo-sphenoidal abscess.

In addition if the function of the pyramidal tract, which normally conveys motor impulses from the cortical "leg centre" be interfered with from pressure, oedema, or other such cause, the plantar reflex becomes extensor in type and slower than under normal circumstances (Babinski). In addition a peculiar fan-like spreading of the toes —*phénomène d'éventail*—is occasionally observed accompanying extension of the great toe.

Paralysis of the muscles of the face upon the side opposite to the existing ear lesion is not uncommon in cases of temporo-sphenoidal abscess, but when occurring upon the same side as the ear lesion it is due to peripheral disease of the nerve in its course through the temporal bone.

The intimate relationship of the third and sixth cranial nerves to the temporo-sphenoidal lobe explains the frequency with which ptosis and convergent strabismus respectively are met with.

Paralysis of the auditory nerve is frequent in cases of cerebellar abscess, especially when due to an original labyrinthine infection. Objective foetor of the patient's breath and body is at times a striking symptom.

Aphasia, motor or sensory, is met with in certain cases of left sided temporo-sphenoidal abscess. The former is the result of pressure, either upon the third left frontal convolution (Broca's) or upon the conducting paths leading from the cortex through the internal capsule or corpus callosum; the latter being due to pressure upon or actual involvement of the upper and posterior part of the first temporo-sphenoidal convolution upon the left side. Further, when the abscess is upon the left side there is often a loss of power of naming objects.

Should the paralysis be of cortical origin the facial muscles are first affected, then those of the arm, and finally those of the leg. When of capsular origin the order is exactly reversed.

Digestive System.—The tongue is furred, the teeth covered with sordes, the breath foetid, the bowels constipated, and the abdominal parietes retracted. Nausea and vomiting are also common, particularly in cerebellar cases, and occur quite independently of the partaking of food. Rapid inanition and consequent loss of weight are also marked features in many cases.

Eye Symptoms.—In a certain number of cases well-marked optic neuritis is present, particularly so in abscess of the cerebellum, less frequently in temporo-sphenoidal abscess, probably because meningitis is a rare complication.

Minor degrees of hyperaemia of the optic disc are not uncommon in intra-cranial abscess, as also in cases of meningitis and thrombo-phlebitis, and even in a small proportion of cases of chronic purulent otitis media (J. S. Barr, p. 227).

In the early stages of the disease the pupils are equal and react to light; as suppuration increases the pupils dilate and ultimately become immobile. The pupil upon the affected side is at times fixed and dilated, whilst that of the opposite side is contracted and mobile.

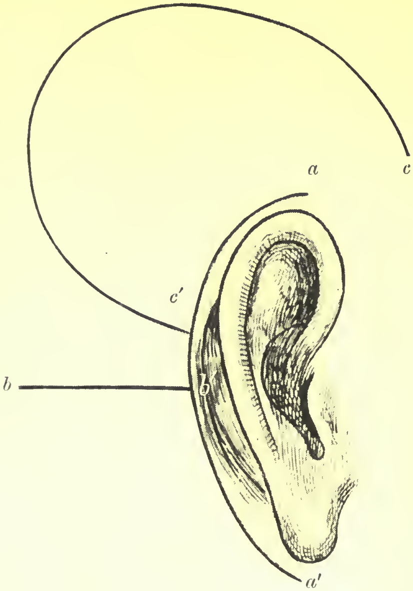

Fig. 197.—*aa′*, Line of incision—complete post-aural operation; *bb′*, for exposure of the knee of the sigmoid sinus; *cc′*, for exposure of the temporo-sphenoidal lobe.

Olfaction.—Anosmia is a symptom met with in many temporo-sphenoidal abscesses if carefully looked for. The cortical centre for smell being bilateral, anosmia occurs upon the side corresponding with the abscess cavity. In latent abscess of the temporo-sphenoidal lobe, less frequently in cerebellar abscess, subjective sensations of foetor are occasionally complained of.

Course and Duration. — The course of a brain abscess is extremely irregular, especially when chronic in type. Occasionally urgent symptoms supervene quite suddenly and death takes place rapidly. Paroxysms of severe pain may be followed by periods of almost complete quiescence.

A fatal issue may result in cerebellar abscess from sudden paralysis of the respiratory or cardiac centres. The duration of a brain abscess is very difficult to determine, from the fact that it may undoubtedly exist without giving rise to any marked symptoms. This is especially the case in abscesses surrounded by a thick capsule. The existence of such a capsule is *ipso facto* a proof of chronicity.

Treatment.—As has already been pointed out brain abscesses tend to develop in the immediate neighbourhood of the septic bone lesion to which they owe their origin. Advantage should be taken of this pathological fact in determining the particular line of exploration.

In all cases, except when the operation has to be performed upon a patient practically moribund, the mastoid antrum and epitympanic recess should be thoroughly exposed and a careful search made for any fistulous tract leading through the tegmen tympani or tegmen antri. In the event of such a tract being found the surrounding bone should be freely removed until a considerable area of dura has been exposed. If, however, no such tract be discovered, the original postaural incision should be continued upwards into the temporal region, the soft tissues freely retracted, and the squamous portion of the temporal bone exposed. Or a crescentic incision may be made from the commencement of the original mastoid incision around the temporal region, terminating about an inch in front of the auditory meatus (Fig. 197). The flap thus formed, with the pinna at its base, is thrown downwards.

A disc of bone, ¾ of an inch in diameter, should now be removed immediately above the external auditory meatus, and in the same perpendicular plane (drainage through the squamous plate), or the roof of the antrum and tympanum may be chipped away so as to expose the base of the temporo-sphenoidal lobe (drainage through the tegmen tympani). A sufficient amount of bone should be removed with Dahlgren's cutting forceps (Fig. 198) to expose the dura over an area of at least 1 to 1½ inches square, and to enable the operator to work without encumbrance. Haemorrhage from the cut surface of the bone is occasionally troublesome but may be controlled by the application of Horsley's wax or by driving a small ivory peg into the bleeding point. Krause's bone hooks are also serviceable, the point of the hook being introduced into the vessel and turned round and round a few times.

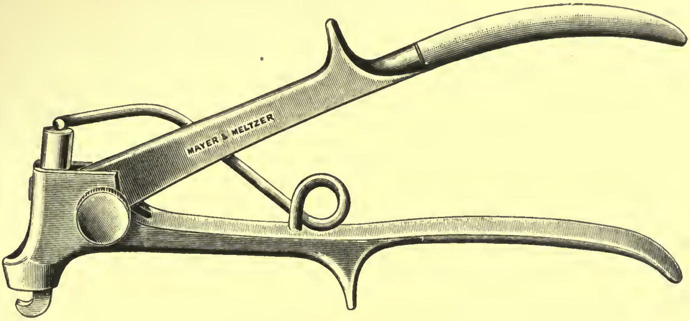

FIG. 198.—Dahlgren's forceps.

In many chronic cases at the site of infection the dura mater, the pia-arachnoid, and the cortex become firmly soldered to one another, and, at times, to the underlying bone. The cortex, from its greater vascularity, is more able to withstand infection than the white substance of the brain, so that around the advancing path of disease a fibrous barrier is thrown out which tends to prevent its diffusion. In the white substance there is, however, no such limiting mechanism, hence the abscess assumes a mushroom-like shape (Preysing), the stalk being formed by the connective tissue barrier within the cortex.

Through this "stalk" drainage takes place, and, from the operative standpoint, should be encouraged to take place.

If a brain abscess be present the exposed dura bulges, as a rule, into the trephine opening, and shows no tendency to pulsate. In the case of a small and deeply seated abscess the dura may, however, not bulge, and pulsation may be visible. Frequently in the immediate neighbourhood of the existing temporal-bone lesion it is found to be discoloured, covered with granulations, or perforated.

When the dura is found to bulge, and no pulsation is visible, it should be incised. A crescentic or rectangular flap is made at a distance of about ¼ of an inch from the margins of the trephine opening, and preferably with a dependent base, care being taken to avoid injury to visible blood-vessels as, from the difficulty of applying catch forceps in such a confined space, haemorrhage may prove troublesome. A protective *tamponade* of the sub-dural space is now made with strips of iodoform gauze.

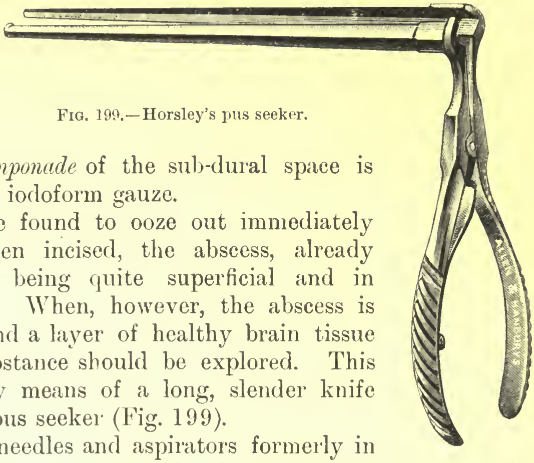

Fig. 199.—Horsley's pus seeker.

At times pus will be found to ooze out immediately after the dura has been incised, the abscess, already localised by adhesions, being quite superficial and in actual contact with it. When, however, the abscess is situated more deeply, and a layer of healthy brain tissue intervenes, the brain substance should be explored. This is best accomplished by means of a long, slender knife (Ballance) or Horsley's pus seeker (Fig. 199).

The various hollow needles and aspirators formerly in use for this purpose have, as a general rule, been discarded from the fact that they so readily become blocked with thick pus or brain substance, and also because they have been known to penetrate an abscess cavity without any pus being withdrawn.

A further advantage of exploration with a knife is that the incision does little or no permanent injury to the cerebral tissue and that it heals rapidly. In exploring for temporo-sphenoidal abscess, the knife should, in the first place, be directed towards the tegmen tympani, and if pus be not discovered, towards the tegmen antri. Failing the discovery of pus in either of these situations incisions may be made in various directions with comparative safety, care being taken to avoid injury to superficial blood-vessels. Should pus be found to well up along the blade of the knife a pair of slender sinus forceps should at once be inserted and opened out so as to permit of a free escape of all purulent debris and broken-down brain tissue. When the operator has to deal with an acute brain abscess in which there is no capsule, the contractile force inherent in the cerebral tissue and the increased tension assist materially in emptying the abscess cavity. Whether or not the cavity should be washed out and a drain inserted must be left to individual judgment. In all the acute cases operated upon by the writer, gentle irrigation with sterilised normal salt solution has been practised and a drain inserted.

To drain the cavity a glass, decalcified chicken-bone, rubber, or silver drainage tube should be employed, or strips of iodoform gauze inserted. In using gauze drainage it is advisable to employ gauze with a selvedge. In the case of an acute abscess one or two strips of gauze should be inserted so as to pack the cavity very lightly. In chronic abscesses, where there is a well-marked capsule, the cavity may be lightly distended with gauze, the packing being introduced between the blades of an opened-up sinus forceps, or through Whiting's encephaloscope. If a drainage-tube be employed it should be brought out through a suitably disposed opening in the skin flap and attached by a couple of sutures to its margins.

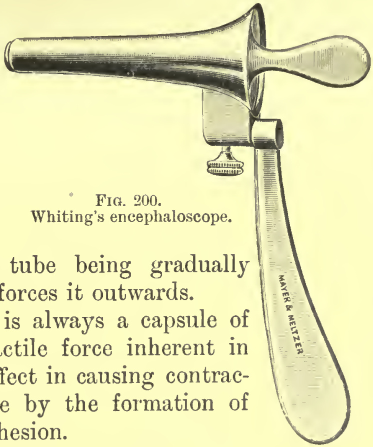

Fig. 200.
Whiting's encephaloscope.

The abscess cavity should be irrigated daily, or every second or third day, according to the amount of discharge found upon the superficial dressings, and its foetor, the tube being gradually shortened as the cavity contracts and forces it outwards.

In chronic abscesses, where there is always a capsule of varying thickness present, the contractile force inherent in the cerebral tissue has little or no effect in causing contraction of the cavity, healing taking place by the formation of granulations, and by their ultimate cohesion.

To inspect the interior of chronic abscesses Whiting has devised an encephaloscope (Fig. 200) which, after sterilisation, is gently introduced into the cavity. Illumination is then effected by means of reflected light. In this way the interior of the abscess is thoroughly examined, and, if need be, curetted.

Once the abscess has been located and drained, a counter opening through the squama or through the tegmen tympani and the insertion of a second tube is of great service, as through drainage is thereby effected. The writer has employed this method of through drainage in the treatment of temporo-sphenoidal abscesses with great satisfaction.

After the abscess has been carefully cleansed or packed with gauze the dura may be sutured and the flap replaced, one tube being brought to the surface through a buttonhole in the skin, the other being brought through the mastoid cavity to the surface. The objection offered to this method of drainage is that the mastoid wound runs the risk of being reinfected. If, however, a tube without perforations be used, and if it be drawn through the mastoid cavity and brought out upon the surface of the skin, the risks of infection are materially lessened. In addition, should the abscess be thoroughly cleansed before the packing in the mastoid cavity is removed, there is little risk of any harm being done.

Terminations.—If unrelieved by operation, death from coma the result of increased intra-cranial pressure, or from the bursting of the abscess into the subdural space or into the ventricle, is practically certain.

In a few exceptional cases absorption of the contents of the abscess and subsequent cicatrisation or calcification of its capsule has been recorded.

It may happen, in the case of an abscess situated near the surface of the brain, that adhesion of the cerebral tissues to the meninges takes place, followed by erosion and subsequent perforation of adjacent bone, through which pus escapes either into the middle ear or mastoid antrum, or under the pericranium.

The writer has seen two cases of temporo-sphenoidal abscess discharge into the middle ear, and two in which perforation took place through the upper and posterior part of the squamous portion of the temporal bone, a collection of pus being found under the pericranium.

In cases not operated upon, death results either from meningitis (about 90 per cent) or from gradual increase in the size of the abscess and its rupture into the lateral ventricle or subdural space, from compression of the cerebral substance, paralysis of the respiratory or cardiac centres, or from gradual asthenia and toxaemia. In a few cases diffuse septic encephalitis results, with or without general pyaemia.

In many instances a brain abscess is accompanied by other intra-cranial lesions such as infective meningitis or thrombo-phlebitis which play a prominent part in producing the fatal issue.

Prognosis.—Modern surgical methods have happily rendered the prognosis of intra-cranial abscess much more favourable than formerly. In uncomplicated cases, provided that the abscess is located and efficiently drained, and that the original focus of disease in the temporal bone is capable of eradication, the chances of complete recovery are favourable, especially in temporo-sphenoidal disease. In cerebellar abscess the possibility of sudden death should never be lost sight of.

The earlier the abscess cavity is opened, and the more efficient the drainage, the better the prognosis; in other words, the prognosis in acute intra-cranial suppuration is more favourable than in chronic.

A leucocyte count is of value from a prognostic point of view. According to C. A. Ballance[1] the prognosis is favourable when there is a high leucocytosis even in the presence of severe and urgent general symptoms, but a slight or absent leucocytosis with severe symptoms is of bad omen.

Cerebellar Abscess.—Cerebellar abscess is stated by most writers to occur about half as frequently as abscess of the temporo-sphenoidal lobe. Of a total of 626 intra-cranial abscesses collected by Heimann, 428 occurred in the temporal lobe, and 198 in the cerebellum, or 68·3 per cent to 31·7 per cent.

Of 532 cases collected by Neumann, 336 were temporal abscesses, and 196 cerebellar, or 63·4 per cent to 36·6 per cent.

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[1] *British Medical Journal*, October 24, 1908.

Cerebellar abscesses are found nearly twice as frequently in males as in females, the largest number of cases occurring between the ages of ten and thirty.

An abscess in the cerebellum rarely attains the same size as an abscess in the temporal lobe, and is, as a rule, more superficially situated. It may be the outcome of acute or chronic suppurative otitis media, more usually the latter. Of 570 cases of otitic intra-cranial abscess tabulated by Heimann, 457 or 80 per cent were due to chronic middle ear suppuration, and 113 or 20 per cent to acute disease. Of 132 cases collected by Neumann, 88 per cent were due to chronic and 12 per cent to acute otitis media.

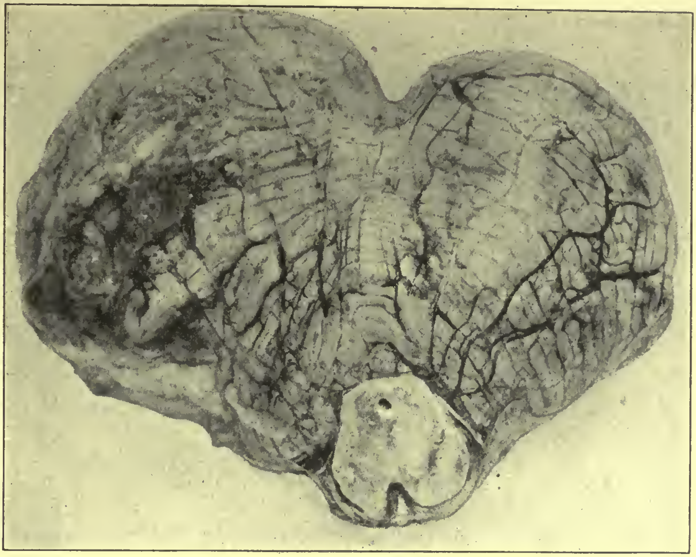

FIG. 201.—Cerebellar abscess, showing superficial situation of abscess and congestion of cerebellar blood-vessels.

The path of infection varies according to whether the abscess is the result of chronic or acute otitis media. In the former, infection by way of the labyrinth is common, in the latter it is rare. In 132 cases of cerebellar abscess due to chronic otitis media, and tabulated by Neumann, the route of infection was in the majority of cases by way of the labyrinth, 43·75 per cent presenting evidences of labyrinthine suppuration, which in 15 of the cases was due to cholesteatoma, and in the others to uncomplicated middle-ear suppuration.

The importance of the aqueductus vestibuli in the incidence of cerebellar abscess is regarded differently by different authorities. In a collection of 65 cases tabulated by Boesch[1] the route of infection through the labyrinth was as follows:—

[1] *Zeitschrift für Ohrenheilkunde*, Band 50.

	Times.		Per Cent.
Via Internal meatus	32	=	49·2
Via Aqueductus Vestibuli	22	=	33·84
Via Porus acust. int. and aqueductus vestibuli	1	=	1·5
Via Acqueductus cochleae	2	=	3
Via Fistula in semicircular canal	8	=	12·3

The rôle played by the saccus endolymphaticus in the production of cerebellar abscess is somewhat uncertain, whilst it must be borne in mind that it, the saccus, may be infected not only from the aqueduct and adjacent area of carious bone, but also from the sigmoid sinus.

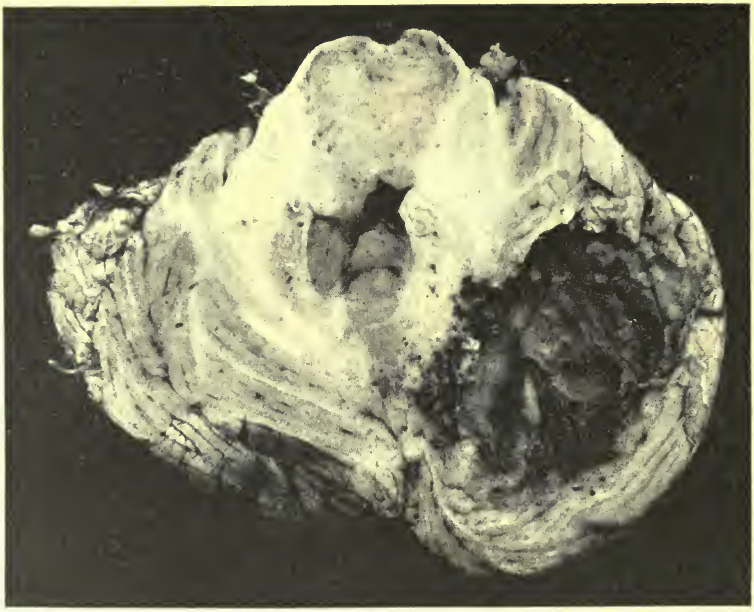

Fig. 202. Large cerebellar abscess with almost complete destruction of left lobe.

With the exception of intermittent attacks of pain many cases of cerebellar abscess run an almost symptomless course. The disease is in the majority of cases essentially chronic, the acute exacerbations which occur from time to time being due to an increase in the contents of the abscess cavity from supplemental infection and meningitis, oedema of surrounding brain tissue, etc. The attacks of pain have seldom any special localising value, and may be due to concomitant caries of the temporal bone, the result of the existing suppurative otitis media. Persistent occipital pain should, however, be regarded with suspicion.

When a cerebellar abscess is secondary to suppurative labyrinthitis it is, as a rule, situated towards the median aspect of the lateral lobe, and when due to suppurative mastoiditis or septic infection of the lateral sinus in the antero-inferior portion of the adjacent lateral lobe.

For clinical purposes the symptoms presented by a cerebellar abscess may be classified under two main headings (1) General; (2) Focal.

General.—Headache is a marked symptom in almost all cases, and is of a dull aching character, with occasional intermittent attacks of acute suffering. Usually the pain is occipital and bilateral, and is aggravated by pressure or percussion over the affected cerebellar area, and by such sudden movements as turning the head. In certain cases the site of the most severe pain corresponds with the situation of the abscess. In others it is complained of principally in the frontal region. When there is, however, a definite and fixed occipital pain, the presumption in favour of the existence of a cerebellar abscess is greatly strengthened.

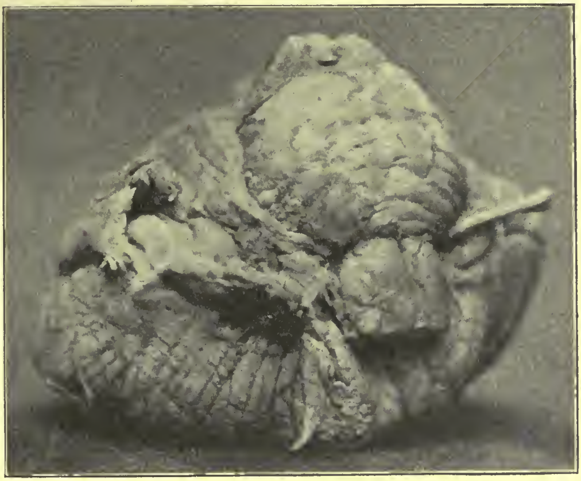

FIG. 203.—Cerebellar abscess in right lobe.

In uncomplicated cases there is, as a rule, no elevation of temperature even when the disease is ushered in by a rigor. The explanation of this remarkable clinical phenomenon is not certain, Nothnagel assuming that the rigor is the result of pressure exerted upon the heat centre in the restiform bodies, Leutert[1] that it is due to a transient serous meningitis, and Hoffmann that it depends upon the existence of a localised purulent meningitis.

According to Broca there is in brain abscess cases an elevation of surface temperature over the affected side of the head. In uncomplicated cases the pulse and respirations become gradually slower and slower and also disproportionate. In those somewhat exceptional cases of cerebellar abscess which run a markedly febrile course, the pulse is seldom quickened except when there is retention of pus in the primary focus of disease in the temporal bone. In the latter stages of the affection Cheyne-Stokes respiration appears. Sudden death from paralysis of the respiratory centre is by no means unusual.

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[1] *Archiv für Ohrenheilkunde*, Band 47.

With progressive increase of intra-cranial pressure there is developed a simultaneous mental lethargy or hebetude, just as in cases of temporal abscess, leading in advanced cases to profound coma from which it is impossible to rouse the patient. Delirium is uncommon.

The position assumed by the patient in bed, viz. lying upon the affected side with the legs flexed upon the abdomen, and the head turned away from the light, is often regarded as characteristic of the disease, but may be due to meningitis, which is nearly always present. When standing erect the patient frequently holds the head stiffly and inclined towards the affected side, or tightly between his hands.

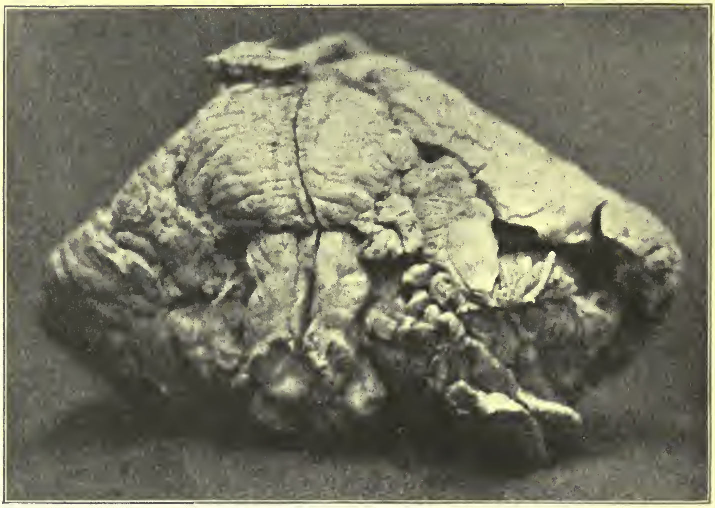

FIG. 204.—Cerebellar abscess in left lobe.

Disturbances of nutrition and rapid emaciation are common in connection with those abscesses which develop as the result of chronic otitis media. Vomiting is an extremely common symptom, is quite independent of the ingestion of food, and in all probability depends upon vestibular irritation. It is much more frequently met with in cases of cerebellar abscess than in temporal lobe abscess. Persistent yawning, accompanied at times by uncontrollable attacks of hiccough, is a common symptom.

Optic neuritis or papillitis occurs in from 30 to 40 per cent of cases of cerebellar abscess, and is decidedly more common than in temporal lobe abscess. Chocked disc is, however, also met with in a small percentage of cases of uncomplicated suppurative otitis media and empyema of the mastoid cells. Its occurrence under such circumstances is said by Körner to be due to inflammation of the lymphatic channels passing between the fundus oculi and middle ear through the carotid canal.

Strabismus and ptosis are also occasional symptoms, the former being due to changes in the neighbourhood of the optic thalami.

Paresis or paralysis of the abducens nerve is not uncommon. As it is also met with in cases of acute otitis media and acute mastoiditis its diagnostic value is not great. Should it occur in combination with paresis of the internal rectus of the opposite side, involvement of the cerebellum may be considered almost certain.

Inequality in the size of the pupils is by no means unusual, the pupil upon the affected side being frequently dilated and fixed.

Owing to the fact that a very considerable number of cerebellar abscesses are consecutive to labyrinthine suppuration, disturbances of hearing are common, and demand careful testing with tuning-forks, Galton's whistle, etc.

Facial paralysis is met with at times in cases of cerebellar abscess, and may be peripheral or occasionally central. When peripheral it may be due to disease in the middle ear, or to pressure of the abscess upon the nerve as it enters the internal auditory meatus, in which case there is paresis or paralysis of the soft palate upon the same side. When of central origin it may be due to pressure of the abscess upon the pons, or to an abscess in the substance of the pons itself.

There exist also in cases of cerebellar abscess certain localising signs and symptoms which are of the greatest practical and clinical value. These signs and symptoms depend upon the size and position of the abscess, and the effect the gradually increasing pressure has upon the cerebellar tissue and cranial nerves in the posterior fossa, the pons, and the medulla. Implication of or pressure upon the various nerve trunks in the posterior fossa affords valuable information, sufficient at times to be of real diagnostic service.

Pressure upon the anterior group of nerves, the fifth and sixth, gives rise to sensory disturbances over the trigeminal area of the same side, and to paresis or paralysis of the external rectus muscle.

The ninth, tenth, eleventh, and twelfth nerves are rarely implicated. Occasionally some defect in articulation may be noticed, which may be due to implication of the palatal branches of the spinal accessory, but which, on the other hand, may be nothing more than the result of the patient's mental condition.

Pressure upon the pons and medulla may give rise to various motor pareses affecting the muscles of the arm or leg upon the opposite side of the body, and to exaggeration of plantar and knee reflexes.

From the fact that the function of the cerebellum is to regulate rather than to originate various complex muscular movements, any implication of its substance has the effect of producing varying degrees of inco-ordination affecting the musculature of the limbs and eyes.

Inco-ordination of gait is very noticeable, in some cases the patient being quite unable to walk in a straight line, staggering towards the affected side, and regaining his balance again with great difficulty.

Similar ataxic movements of the muscles of the arm and forearm, accompanied by tremors, are also noticed when the patient is asked to touch any specific object.

Babinski has drawn attention to a peculiar interference with the normal movements of pronation and supination occurring in cerebellar lesions and which he has named "dysdiadokokinesis." In the case of a person suffering from cerebellar abscess the movements of pronation and supination are performed clumsily with marked irregularity and with the aid of associated movements of the elbow and shoulder joint of the affected side. This symptom, which is fairly frequently met with, possesses considerable localising value.

Ataxia due to cerebellar abscess is characterised by inco-ordination of muscular movements upon the same side of the body with or without hemiparesis. Vestibular ataxia is best demonstrated by means of Romberg's test.

Marked weakness of the conjugate movements of the eyes is common.

Focal Symptoms.—Focal symptoms of cerebellar abscess are due to lesions of Deiter's nucleus and the afferent and efferent nerve tracts leading from and to it, and to lesions of the sensory tracts affecting the same side of the body.

Lesions of Deiter's nucleus induce varying degrees of vertigo, nystagmus, and inco-ordination of movements, while lesions of the sensory tracts are followed by hemiparesis and hemiataxia of the upper and lower extremities of the same side of the body.

Nystagmus of cerebellar origin must be very carefully differentiated from that due to lesions of the semicircular canals.

Cerebellar nystagmus is always greater towards the affected side, and increases *pari passu* with the advance of the disease. Labyrinthine nystagmus, on the other hand, is at first directed towards the affected side, but as the lesion advances, inclines towards the sound side, and remains directed towards the sound side until the labyrinth is completely destroyed, when it ceases altogether.

In addition, the irritability of the labyrinth varies with the progress of the disease. In circumscribed lesions and when nystagmus is directed towards the affected side, the irritability is unimpaired, but as the disease advances and the direction of the nystagmus changes towards the sound side, the irritability of the labyrinth to both caloric and rotation tests will be found to become more and more impaired until it finally becomes abolished.

As, however, cerebellar abscess and suppurative labyrinthitis frequently co-exist, the former being the outcome of the latter, a differential diagnosis between nystagmus of cerebellar and labyrinthine origin must be made.

According to Bárány, the following indications are of value:—

1. If nystagmus towards the affected side exists, either a circumscribed labyrinthitis or a cerebellar abscess may be present.

2. If rotary nystagmus towards the affected side is present, and the labyrinth is no longer irritable, a diagnosis of cerebellar abscess may be made, if, in addition, there co-exists a slow pulse and a low temperature.

3. If nystagmus towards the sound side exists, and the labyrinth is non-irritable, the lesion may be in either labyrinth or cerebellum, and an exact diagnosis is impossible until the labyrinth has been opened. If of labyrinthine origin, it disappears within a few days of the performance of the operation; whereas, if of cerebellar origin, it not only goes on increasing in intensity, but may change its direction and incline towards the affected side.

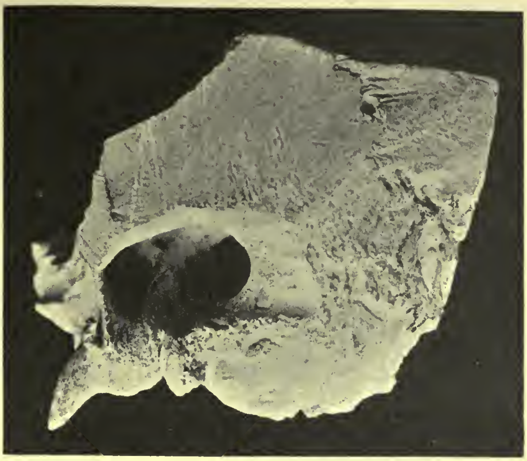

FIG. 205.—Temporal bone, showing opening through the posterior wall of mastoid antrum to expose the anterior surface of the lateral cerebellar lobe.

Terminations. — A fatal termination is practically certain unless the abscess is relieved by operation or by spontaneous evacuation, death resulting from sudden respiratory failure, rupture of the abscess upon the surface of the brain or into the fourth ventricle, or from the induction of meningitis due to extension of inflammation from the area of infected brain tissue around the abscess cavity. When rupture takes place into the pia-arachnoid there is a rapid rise of temperature accompanied by great restlessness, irritability, and delirium, muscular contractions, opisthotonos, trismus, etc.; if into the ventricle, sudden maniacal symptoms are not infrequent, accompanied by rapid rise of temperature, rapid respiration and rapid pulse.

Both tonic and clonic contractions of various muscles or groups of muscles are common, and frequently precede an attack of profound coma from which the patient does not recover.

In exceptional cases spontaneous evacuation of a cerebellar abscess may take place (MacEwen, Pollak, Mück), or the abscess may become absorbed and its capsule calcified.

Prognosis.—In all cases a guarded prognosis should be given. From an analysis of available statistics the mortality varies from 65 to 75 per cent, the chief cause of death being an associated meningitis. The fact that more than one cerebellar abscess may be present, and that a cerebellar and temporal lobe abscess may exist at one and the same time, must always be borne in mind. Also the fact that a cerebellar abscess may have one or more diverticula which it may be difficult to drain efficiently is a point to be taken into serious consideration. Temporary improvement frequently follows escape of the contents of the abscess cavity, while relapses take place as it fills up again.

The most favourable cases are those in which the abscess is small and superficially situated.

In cases of large cerebellar abscesses which have been opened through the median antral wall, a counter opening behind the sinus should always be made to permit of thorough irrigation being effectually carried out, and, if necessary, the walls of the cavity curetted. A large drainage-tube wrapped round with iodoform gauze should be introduced into the abscess, the drainage-tube permitting of the escape of the larger particles of necrotic brain tissue, and the gauze forming a more or less permanent "wick" for the fluid contents of the cavity.

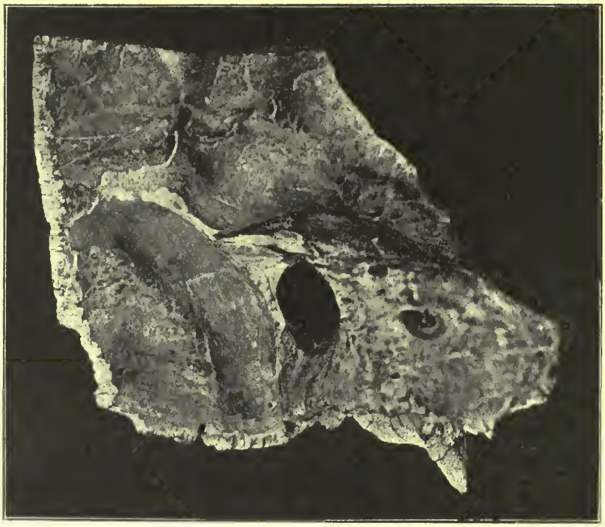

FIG. 206.—Posterior surface of temporal bone showing opening between the sigmoid sinus groove and the internal auditory meatus for exploration for cerebellar abscess.

Treatment.—From the fact that the larger number of cerebellar abscesses are situated in the anterior and median portions of the lateral lobe of the cerebellum, the most suitable route for operation is through the posterior wall of the mastoid antrum, between the sigmoid groove and the internal auditory meatus (Fig. 205). By this route the abscess is, as a rule, much more readily found, and the primary focus of suppuration is obliterated at the same time. Exposure of the anterior surface of the cerebellar lobe in this situation is comparatively easily effected after the performance of the complete post-aural operation, a space of from 0·5 to 2 c.m. in breadth being available. The bone in this situation is frequently softened by caries, and is at times perforated by a fistulous channel leading towards the abscess cavity.

The opening made should be as large as possible, care being taken on the one hand to avoid injury to the walls of the lateral sinus, and on the other not to carry it too far inwards for fear of wounding the auditory and facial nerves which lie at a distance of three-quarters of an inch from the anterior margin of the groove for the lateral sinus.

The dura having been exposed should be carefully opened and the cerebellum explored in a manner similar to that already described in the case of abscess of the temporo-sphenoidal lobe. A rigid drainage tube should be introduced and brought out through the mastoid wound to the surface of the skin to which it should be attached.

If, on the other hand, there is reason to believe that the abscess is situated in the lateral portion of the cerebellum, the following method of procedure may be adopted. An incision with its convexity downwards is made from the tip of the mastoid process to the region of the occipital protuberance, and the flap thus formed folded upwards. After all bleeding points have been ligated a disc of bone is removed with a $\frac{3}{4}$-inch trephine, the centre of the circle being situated at a point $1\frac{1}{2}$ inch behind the centre of the external auditory meatus upon Reid's base line and $\frac{1}{2}$ inch below it. Removal of a disc of bone in this situation may be safely effected without injury to the horizontal or descending portions of the lateral sinus. More bone may also be safely removed in a downward and backward direction by means of Citelli's forceps, but should it be essential to remove it anteriorly great care should be taken, otherwise the walls of the lateral sinus may readily be injured. As, however, sinus phlebitis frequently co-exists with cerebellar abscess, it may be necessary to freely expose the whole surface of the sinus, to follow it backwards towards the torcular and downwards towards the jugular bulb.

For this reason, whenever circumstances permit, the complete operation should be performed as a preliminary step, partly from the fact that septic invasion of the sigmoid sinus and of the cerebellum is frequently due to chronic mastoiditis, and partly also because the sinus can be so readily exposed by so doing.

When, however, the patient is *in extremis*, and rapid evacuation of pus is called for, the performance of the complete post-aural operation may be deferred. The dura having been freely exposed is examined carefully; in the event of its bulging, and no pulsation being visible, a flap should be cut and the surface of the cerebellum exposed. A long and thin knife should now be inserted into its substance, and exploration made, as has already been described, in the treatment of abscess of the temporo-sphenoidal lobe.

During exploration for cerebellar abscess, failure of respiration may suddenly supervene from pressure upon the medulla, inducing paralysis of the respiratory or cardiac centres. Under such circumstances artificial respiration should at once be resorted to and kept up while the operator proceeds as quickly as possible to expose and to explore the cerebellum.

The writer has met with 4 such cases of sudden respiratory paralysis during operation. In each artificial respiration was kept up, and rapid evacuation of the abscess successfully accomplished.

To lessen the risk of such sudden paralysis the writer has suggested (*J. of L.* vol. xix., 1904) the performance of a lumbar puncture, and the withdrawal of a small amount of cerebro-spinal fluid before exploration is undertaken. This preliminary spinal puncture has been objected to[1] on the grounds that the sudden withdrawal of fluid and consequent diminution of intra-cranial pressure may cause rupture of a superficially situated abscess. If, however, the withdrawal be gradual, and the amount withdrawn small, there should be no risk.

After-Treatment.—The great essential is to secure the maintenance of free and unimpeded drainage. The gauze filling the mastoid cavity should be carefully disposed around the tube so as to support, and at the same time to soak up, secretion from the mastoid wound. As a rule, the external dressings should be removed each day, or every second day, in order to see that drainage is being maintained, and that the tube has not become plugged with secretion or brain substance. As the tube tends to be forced out by the gradual contraction of the abscess cavity it may be shortened. In acute abscesses contraction takes place much more rapidly than in chronic abscesses, which have a capsule of varying thickness and resistance, and from whose lining pus continues to be secreted for weeks.

In acute cerebellar abscesses irrigation may or may not be practised; in chronic abscesses it should be employed every second or third day.

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[1] E. C. West, *Trans. Otol. Soc.* viii.

CHAPTER XXXI

SINUS PHLEBITIS AND SINUS THROMBOSIS

Sinus Phlebitis and Sinus Thrombosis.—Of the various intra-cranial complications following suppurative middle-ear disease, phlebitis of the sigmoid sinus with subsequent thrombosis is the most frequent. It may occur as the result of acute or chronic purulent otitis media, usually the latter, and is more prone to take place in those cases in which the mastoid process is of the pneumatic variety, the cells of large size, having thin walls, and in close relationship with the sigmoid groove. It occurs most frequently in the sigmoid portion of the sinus and in the bulb as the result of infection through the tympanic floor. The resulting phlebitis may lead to complete or incomplete (mural) thrombosis, while the thrombus itself may be localised to that portion of the vessel in the immediate neighbourhood of the original septic focus,

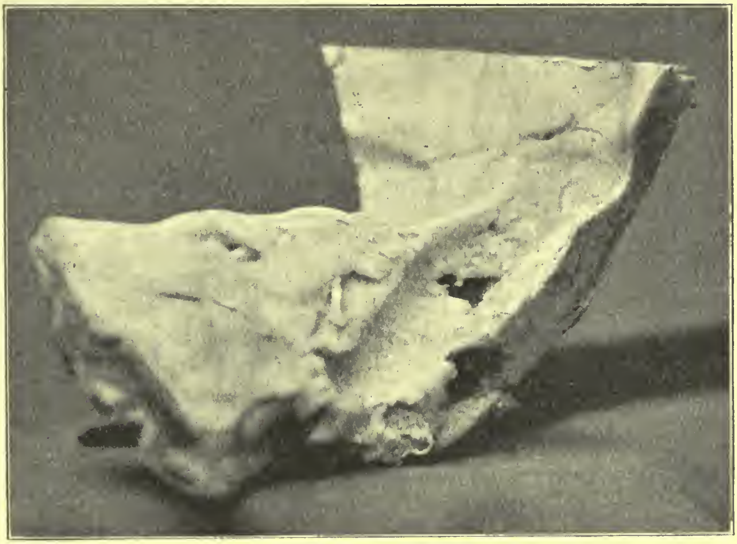

FIG. 207.—Temporal bone; caries of sigmoid groove.

or may extend backwards to the torcular, downwards to the bulb and jugular vein, inwards along the superior and inferior petrosal sinuses, or outwards along the emissary mastoid vein. Phlebitis without thrombosis is stated to occur at times as the result of the pressure from an extra-dural abscess.[1]

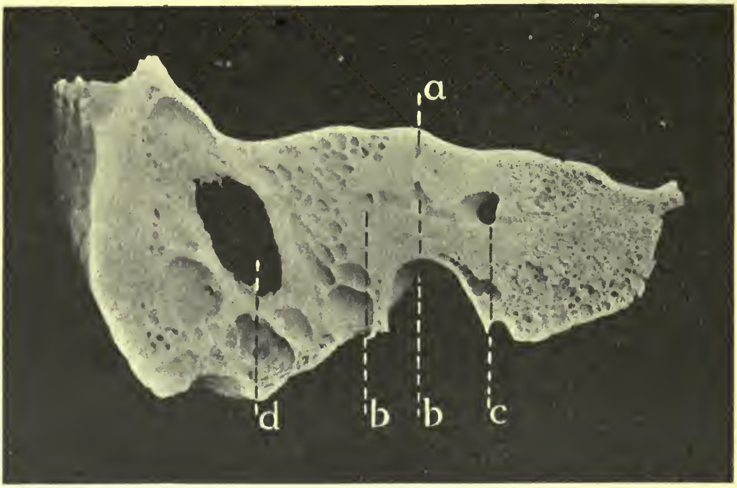

Fig. 208.—Section of temporal bone (at the level of the groove for the sigmoid sinus). *a*, Superior semicircular canal; *bb*, superior and posterior semicircular canals; *c*, internal auditory meatus; *d*, groove for the sigmoid sinus.

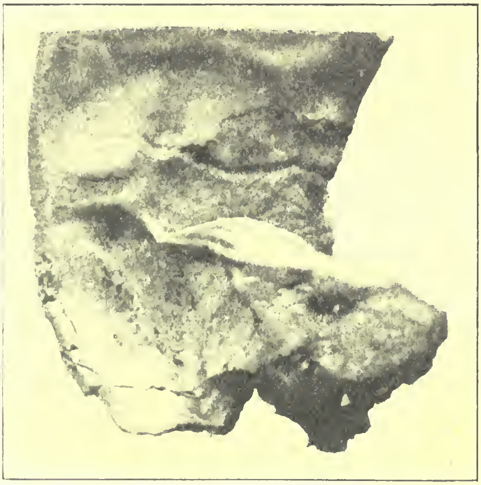

Fig. 209.—Temporal bone, showing carious erosion of groove of sigmoid sinus from a case of chronic suppurative otitis media.

The usual paths of infection are the result of progressive carious erosion of the bony wall intervening between the infected mastoid cells and the sigmoid groove (Figs. 207 and 209), or through the floor of the middle ear, more especially when a high jugular bulb is present (Fig. 211), or from thrombosis of minute venules running between the lining of the mastoid cells and the walls of the sinus itself. In exceptional cases a dehiscence in the floor of the cavum tympani is present, permitting of an actual contact of the diseased tympanic mucosa with the walls of the jugular bulb, while in children more especially the plate of bone forming the floor of the middle ear is so thin as to offer very slight resistance to the passage of septic organisms towards the bulb.

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[1] Krause, *Archives of Otology*, December 1908.

Pathology. — Sinus phlebitis may occur with or without suppuration in the sigmoid groove. It may or may not occur in the presence of granulation tissue on its walls.

Although it has been suggested that thrombosis may happen without the entrance or presence of bacterial infection, our experience points to the fact that infection is the rule, although the gross features of its presence may not be observed at the moment of exploration.

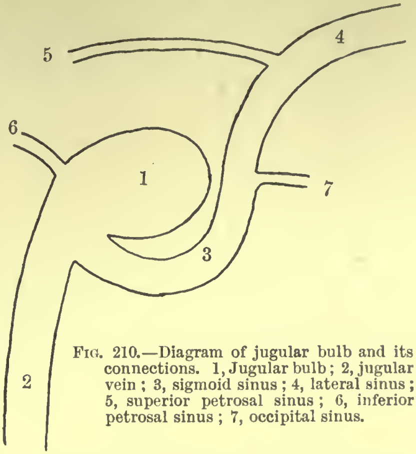

Fig. 210.—Diagram of jugular bulb and its connections. 1, Jugular bulb; 2, jugular vein; 3, sigmoid sinus; 4, lateral sinus; 5, superior petrosal sinus; 6, inferior petrosal sinus; 7, occipital sinus.

Infection of the sinus may take place directly through its walls by means of the *vasa vasorum* at the seat of bone perforation, or by means of the numerous venous radicles and tributaries which enter the venous tract above or below the actual seat of disease, such as the superior petrosal sinuses, mastoid veins, and the peri-vascular lymph spaces which communicate between the infected antro-tympanic cavity, labyrinth, and mastoid element and the inferior petrosal sinus entering the jugular sinus.

Sections of an excised jugular bulb show that the thrombosis may be complete or only peripheral. In

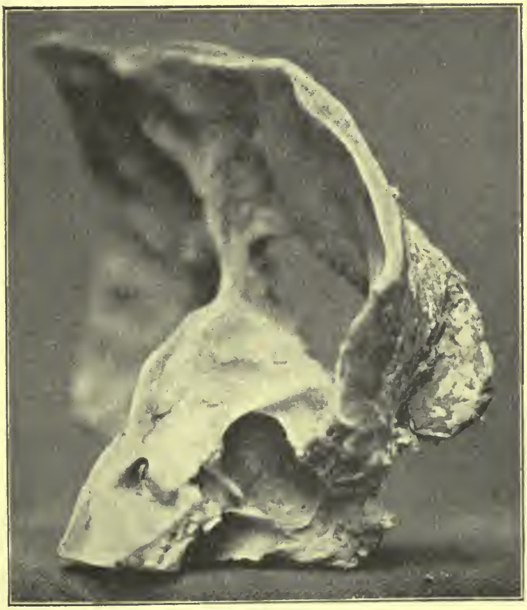

Fig. 211.—Temporal bone caries of sigmoid groove and large jugular fossa.

the lower portion the clot is tapering, there being a space between it and the walls of the vein. At its upper part when incomplete the reverse is the case, its central portion being fluid.

That portion of the clot which is nearest to the wall is generally composed of pure closely packed fibrin with but few leucocytes, but towards its centre it is redder and contains erythrocytes entangled in a loose meshwork of fibrin.

The walls of the vein are normal, but the endothelium exhibits a granular condition of its cytoplasm. In mild cases the thrombosis frequently extends only along the walls (mural thrombosis), in more severe infections the whole lumen becomes rapidly occluded.

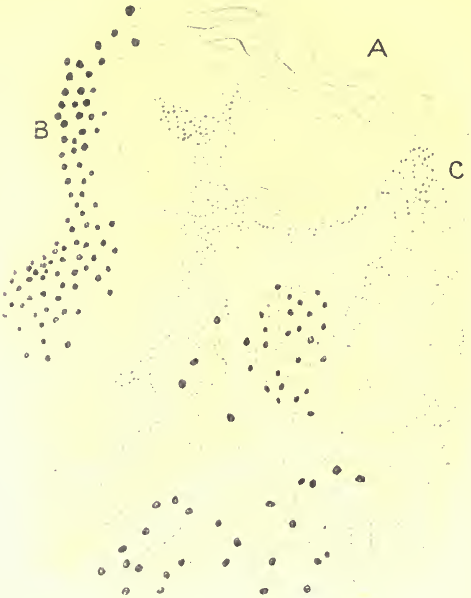

Fig. 212.—Streptococcal infection of wall of sigmoid sinus. Obj. $\frac{1}{8}$ in. A, Necrosed wall of sinus; B, leucocytes and lymphocytes; C, streptococci.

Sections of the wall taken from the sigmoid sinus show, however, marked congestion of the *vasa vasorum*, absence of endothelium, and a distinct accumulation of leucocytes which have invaded its fibrous walls forming distinct spaces. The peri-vascular lymph channels of the *vasa vasorum* are also crowded with leucocytes (Fig. 212).

Examination of the clot shows bacteria of many kinds, the most frequent forms being *streptococci*, *diplococci* (Gram –), and *staphylococci*. Less commonly found are *pneumococci*, *streptothrices* (Gram +), *bacillus coli communis*, and *bacillus proteus vulgaris*. *Spirochaetae* were found in the peri-dural pus in two instances. Bacteria were also seen in the peri-vascular lymph spaces.

Cultures of all these were obtained from the clot.

Symptoms.—The advent of phlebitis of the sinus may be very gradual, or may supervene suddenly, according to the duration of the original antro-tympanic infection and its pathogenicity.

The occurrence of a rapid rise of temperature, accompanied by a rigor or by a feeling of chilliness in the case of an already existing purulent otitis media, should invariably suggest the probability of a commencing septic phlebitis. The temperature from being normal or practically normal, may suddenly shoot up to 102°, 104°, or even 106° F. and may just as suddenly drop to normal or sub-normal. This sudden rise is in about 40 per cent of cases accompanied by a marked rigor, and its fall by profuse sweating. In other cases, however, no definite rigor takes place, the patient merely having the sensation of chilliness, which may be of such short duration as to escape attention. The rise of temperature may, however, be gradual, and may not exceed 102° F.

In cases of severe infection two or three rigors may occur during the twenty-four hours, in mild cases only a feeling of chilliness, followed by clamminess of the face, hands, and feet. As a rule, the profuse sweating which takes place occurs as the temperature falls, although in some cases it is fairly continuous, and serves to still further weaken the already exhausted patient. In cases of exceptional severity, sweating may be so profuse as to soak the patient's night clothes and bed linen. When rigors do not take place the skin remains dry.

In uncomplicated cases the pulse-rate corresponds fairly accurately with the rise and fall of temperature. When, however, there is an associated intra-cranial abscess the temperature curve may still show violent oscillations, whilst the pulse-rate falls to normal or sub-normal. If associated with meningitis, both pulse-rate and temperature curve remain much above normal.

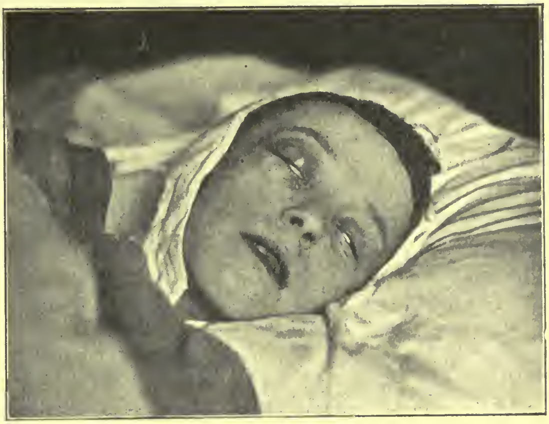

FIG. 213.—Protrusion of eyeball and oedema of eyelids in a case of thrombosis of the cavernous sinus secondary to chronic purulent otitis media.

The number of respirations varies with the acuteness of the infection and the presence or absence of intra-cranial or pulmonary complications. In the advanced stages of the disease, when infection of the lung has taken place and patches of embolic pneumonia are present, the number of respirations may be from 30 to 40 per minute.

Pain over the affected mastoid and region of the sinus is usually present, and may be severe. Should the phlebitis extend along the course of the jugular vein in the neck, or should a secondary cellulitis and infection of the cervical glands result, it becomes a prominent symptom, and is aggravated by palpation and by movements of the head and neck. Torticollis is also occasionally met with. At times a deep-seated cervical abscess results, accompanied by the formation of an elongated oval swelling of the superimposed tissues.

As phlebitis and secondary thrombosis extend, the various collateral tributaries which empty their blood into the internal jugular vein may become occluded with the production of such objective indications as oedema of the face from blocking of the facial vein, oedema of the soft tissues over the mastoid and occipital areas from blocking of the mastoid emissary vein (Griesinger's symptom), protrusion and displacement of the eyeball from occlusion of the cavernous sinus and ophthalmic vein (Fig. 213), and paralysis of the hypoglossal nerve from the pressure of an occluded condylar vein in its passage through the anterior condylar foramen.

Paresis or paralysis of the spinal accessory, glosso-pharyngeal, or vagus nerve is also occasionally met with when the bulb is thrombosed.

Optic neuritis is present in nearly 40 per cent of the cases.

Vomiting of the cerebral type occurs, as a rule, during some stage of the disease. Vertigo is met with in those cases when there is a co-existing labyrinthine lesion, seldom in uncomplicated cases.

In the early stages of the disease the tongue is white and furred, the breath foetid, the teeth covered with sordes, and the bowels constipated. In its later stages the tongue becomes dry and glazed, and there are frequent attacks of diarrhoea. As a rule, there is little or no interference with the patient's mental condition, the mind remaining perfectly clear almost up to the last.

As the disease progresses the clot becomes softer, until finally it begins to disintegrate. Detached particles are carried by the general venous stream towards the right side of the heart and thence into the lungs. In the majority of cases these emboli become lodged in some portion of the pulmonary tissue, there to cause infarcts with resulting septic pneumonia, abscess, or gangrene of the lung. Minute emboli are at times, however, carried through the lungs, and so into the general arterial stream, and deposited ultimately in such organs as the liver, kidneys, spleen, or brain, or in the joints or muscles of the arm or leg.

In a certain number of cases no clinical symptoms are present, the thrombosed condition being discovered accidentally during the performance of the complete post-aural operation. In such cases, the knee of the sinus may be found thrombosed, covered with granulation tissue, or actually perforated and discharging pus into the adjacent mastoid area. Under such circumstances the condition may be looked upon as one of localised abscess in the sinus, protective clots above and below the infected area preventing general infection.

Diagnosis.—The presence of the existing purulent middle-ear disease, the high temperature with frequent and marked oscillations, the rapid pulse, and the tenderness over the sinus and along the course of the jugular vein, are highly suggestive of the existence of lateral sinus thrombosis. Advantage should also be taken of the information derived from a blood-count, a high degree of leucocytosis, 15,000 to 30,000, in the presence of the already detailed symptoms being suggestive, while the presence of large numbers of mono-nuclear leucocytes is indicative of the formation of pus.

The disease may be mistaken for typhoid fever, pneumonia, or malaria, especially if suppurative otitis media is unrecognised.

From typhoid fever it may be distinguished by the rapid oscillations of temperature with repeated rigors, by the absence of petechiae, by a negative Widal reaction, and by the blood-count.

In addition, if the acute otitis began first, followed by high temperature and pain, a diagnosis of sinus thrombosis is much more likely, as exudative catarrhs in typhoid fever are rarely found before the end of the third week.

From pneumonia, especially a central pneumonia, it is at times difficult to differentiate. The presence of cough, rusty sputum, and the more even, although elevated temperature, serve as good differential diagnostic symptoms.

The results of a blood examination and the presence of the *plasmodium malariae* serve to indicate the existence of malaria.

In doubtful otitic cases it is advisable to perform a post-aural operation in order to expose the sinus and, if necessary, to explore it.

Prognosis.—Should the case be seen at an early stage, and before general systemic infection has taken place, the prognosis is good, provided that the infected clot is thoroughly cleared out, and, if deemed essential, the internal jugular vein ligatured. If, however, the disease has been present more than a week or ten days, systemic infection is practically certain and the outlook bad, although not necessarily hopeless, provided that a very thorough operation is at once performed and suitable vaccine or serum treatment instituted.

The advent of septic pneumonia, gangrene of the lungs, etc., renders the outlook hopeless and operation useless.

Complications.—The complications of lateral sinus thrombosis may be (1) intra-cranial; (2) systemic.

The principal intra-cranial complications are meningitis and cerebellar abscess, the former set up, as a rule, by extension of infective thrombosis along the petrosal sinuses, the latter by direct infection of adjacent cerebellar tissue The various systemic complications, such as pneumonia, pleurisy, abscess of the liver, septic jaundice, septic renal infarcts, septic synovitis, etc., are metastatic.

Treatment.—If a diagnosis of septic infection of the lateral sinus has been made, no time should be lost in exposing the area of disease, and in occluding the main blood-stream in order to prevent systemic infection from detachment of septic emboli.

The objects aimed at are (1) complete clearing out of all septic disease in the tympanic and mastoid area; (2) exposure of the sigmoid sinus; (3) exploration of the sinus, and if necessary, the bulb, and the clearing out of the infected clot if purulent; (4) ligature of the jugular vein and, if deemed necessary, its removal by dissection; (5) vaccine and serum treatment to counteract general infection.

Operation.—The patient's head having been suitably prepared and the skin of the operation area and its immediate surroundings rendered aseptic, the complete post-aural operation (page 323) is first performed. The bone intervening between the mastoid cavity and the knee of the sigmoid sinus is removed by means of a gouge or bone forceps, and the sinus wall brought into view. Sufficient bone should then be cut away to expose from $\frac{3}{4}$ inch to 1 inch of the sinus, in order to afford the operator ample room to investigate the condition of its walls, and to subsequently clear out the clot, should one be found.

The anatomical position of the sigmoid sinus varies greatly. In some cases it is situated superficially, and approaches close to the posterior wall of the auditory meatus, in others it lies deeply and is separated from the meatus by an intervening layer of cellular tissue of varying thickness. In brachycephalics it is said to be situated farther forwards and outwards than in dolichocephalics. According to Politzer, the sinus is less likely to be injured in pneumatic processes (where it lies more deeply and farther away from the osseous meatus) than in diploetic or pneumo-diploetic mastoids.

From the clinical standpoint it is impossible to foretell its exact position, hence operative opening of the mastoid should always be conducted with great caution.

A preliminary *x*-ray examination gives, in certain cases, an idea of its anatomical relations. According to Lange,[1] if a postero-lateral negative be taken, the pyramid is thrown forwards and the position of the sigmoid groove shown. Various other practical details pertaining to the anatomy of the mastoid process are also to be noted in this way.

The sinus should be gently separated from the overlying bone by means of some flat instrument, so as to lessen the risk of injuring it and to facilitate the action of the bone forceps. In some cases it may be necessary to cut away bone over the lateral sinus as far backwards as the torcular and as far downwards as the bulb.

After free exposure of the sinus and evacuation of any peri-sinusal abscess which may be present, its walls should be carefully examined. If no thrombus be present the vessel will appear of a dark-bluish colour, and may be seen to pulsate synchronously with the respiratory movements.

If, however, a thrombus be present, it will present a greyish or yellowish-grey colour. When a peri-sinusal abscess has been present, the walls may be found studded with granulations which, serving as they do as nature's first line of defence, are in favour of the sinus not being thrombosed. On account of the ease with which particles of clot may become detached by palpation of the sinus, all unnecessary digital manipulation should be avoided.

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[1] *American Quarterly of Roentgenology*, December 1909.

To determine the presence or absence of a clot, aspiration with a hypodermic needle, or slitting up of the exposed wall of the sinus may be practised. Aspiration is not, however, entirely free from risk, on account of the possibility of infecting a hitherto healthy sinus, and also because, owing to the possible existence of a slight degree of mural thrombosis, blood may still be drawn and so deceive the examiner. In addition it may happen that the existing thrombosis is located, not in the sigmoid sinus itself, but in the petrosal sinuses or bulb of the jugular vein. This latter phenomenon is by no means uncommon, especially in the case of children where the floor of the middle ear is often very thin, and direct transmission of infection is consequently favoured.

If aspiration be carefully performed, the wall of the sinus having been previously cleansed by soaking in peroxide of hydrogen solution, the information obtained is often of great value. If no blood be withdrawn the evidence of an existing thrombosis is complete. If blood be withdrawn it should be squirted on to a white enamelled vessel, carefully examined microscopically, and smelt. If infected the colour may be reddish-brown, and a distinctly foetid odour is occasionally noted. Incision of the sinus wall renders the diagnosis certain, and should invariably be practised when symptoms point to the existence of thrombosis. Even in doubtful cases it is preferable to at once explore the sinus rather than to await developments, and to find in the course of a few days that the sinus is entirely blocked with a septic thrombus which had probably been present from the commencement. To open the sinus a sharp-pointed curved bistoury or scissors should be used, an incision of at least three-quarters of an inch being made through its coats.

When thrombosis is found to be present the operator has to determine whether to immediately tie the jugular vein before removing the clot, or to first get rid of the clot and subsequently to tie the vein, or to remove the clot and leave the vein alone, or to leave the clot alone.

Whether the jugular vein should be ligatured or not, and whether it should be ligatured before or after exposure of the sinus, are points upon which opinions differ. Much depends upon whether the clot is septic or not.

The chief arguments against ligature of the vein are: (1) that even if ligatured dissemination of infected material is not necessarily prevented on account of the many tributaries which open into it and which may still become infected; (2) that it prolongs the primary operation and materially adds to its risks; (3) that the altered state of the circulation may induce acute cerebral oedema.

In favour of ligature there is, however, the satisfaction of knowing that the main channel of systemic infection has been cut off, and that statistics on the whole go to show that there is a larger percentage of recoveries in those cases in which the vein has been tied than in those in which it has not.

The vein should invariably be ligatured before exposure of the sinus in those cases:

1. When it is obviously infected, in other words when there is marked tenderness along its course, swelling and oedema of the cervical cellular tissue, and the presence of enlarged and tender glands.

2. When the condition of the patient is so serious that the operation must be performed in stages. In such cases a primary ligature of the vein gives the patient a better chance.

3. When infection of the bulb has been definitely diagnosed.

The vein should be ligatured after exposure of the bulb if (1) it be found impossible to clear out the whole of the infected clot from above; (2) if in the course of operative procedures infection of the bulb is discovered; (3) if after clearing out the sinus a subsidence of symptoms does not take place, indicating that the whole of the infected material has not been got rid of; (4) if secondary septic cellulitis of the tissues of the neck upon the affected side should take place.

The writers are in favour, after a somewhat extended experience of cases in which the vein has been ligatured, and of others in which it has not, of invariably tying the vein either before or after exposure of the sinus in all cases except those when it is obvious that the condition of affairs may be looked upon as a purely *localised* abscess of the knee of the sinus. Even if the thrombus is small and firm in consistence, the walls of the sinus apparently healthy, and systemic infection slight, it is advisable to clear out the clot and ligature the vein.

Should difficulty be experienced in finding the vein, the surgeon should seek the facial vein at about the level of the great cornu of the hyoid bone, and follow it downwards until it enters the internal jugular. If the jugular vein is patent it will be of a dark-bluish colour, and will be seen to fill up and to collapse with respiration; if thrombosed it may present a bluish or cream-coloured appearance, according to the condition of the contained thrombus, and will be found collapsed and incapable of pulsation.

In the event of its being desirable to first of all tie the jugular vein, an incision is made along the anterior border of the sterno-mastoid muscle, from the tip of the mastoid process to the level of the cricoid cartilage, the patient's head being extended and turned to the opposite side and the neck supported on a sand-bag. The skin, superficial fascia, and platysma muscle having been divided, the anterior border of the muscle is exposed and drawn outwards by means of a rake retractor. The sheath of deep cervical fascia enveloping the jugular vein, internal carotid artery, and vagus nerve is now exposed, picked up with forceps, snipped with scissors, and carefully opened by means of a blunt-pointed director. If pressure be made upon the vein low down in the neck it becomes more prominent even if blocked by clot, on account of collateral circulation. In this way the vein, which lies superficial and external to the internal carotid artery, is brought into view. An aneurism needle is now introduced from within outwards under the vein, and in this way it is separated from the carotid artery which lies internal to it, and from the vagus which lies between and behind. By gentle outward traction with the aneurism needle it is always possible to make sure that the vein is separated from the nerve. Two ligatures are now passed round the vein ½ inch apart, the vessel tied in two places, and divided midway between the ligatures.

Ballance has suggested that the lower end of the upper portion of the cut jugular vein should be stitched to the skin in order that it may act as a drain, and permit of thorough irrigation being effected.

When the walls of the jugular are infected it is advisable to dissect the vein from the neck as far upwards and towards the bulb as is possible. The various tributaries emptying into the main stem should be tied and divided as they are encountered, and in the event of their being themselves thrombosed, followed up and ligatured as far away from the seat of disease as possible.

Another method advocated by Kennon[1] is to resect the jugular from the level of the facial vein to the clavicle and to stitch its upper end to the skin, so as to prevent infection of the cellular tissues of the neck from the cut end of the vein at the base of the skull.

After incision of the sinus wall free haemorrhage may take place, either because no thrombus exists, or because occlusion is not complete, as occurs in cases of mural thrombosis. It may also happen that the thrombus is situated in the jugular bulb, in which case bleeding takes place from a non-occluded inferior petrosal sinus. The operator must therefore be prepared to arrest the free flow of blood should it occur. For this purpose it is necessary to have at hand two plugs of sterile gauze to occlude the lumen of the sinus. One plug should be placed over the upper and the other over the lower end of the exposed sinus and held in position by an assistant. If after incision free bleeding occurs, pressure should be made upon the one plug, and then upon the other, to ascertain from which direction it takes place. Should it come from the upper end of the sinus it is obvious that no thrombosis exists towards the torcular, and if from its lower end the deduction is that it is from the region of the bulb by way of a non-occluded inferior petrosal vein. To arrest the haemorrhage the plug may be introduced into the sinus and left there, or the wall of the sinus may be folded inwards and retained in position with gauze packing. Another method adopted by some surgeons is to introduce a plug of gauze between the detached sinus wall and the overlying bone.

The clot is then scraped out of the sinus with a curette. Should it be extensive it may be and frequently is necessary to cut away more bone in the direction of the torcular. This may be effected by means of bone forceps, the sinus wall being carefully separated from the overlying bone with a flat and narrow spatula. When the distal end of the clot has been completely removed free bleeding takes place, and should be allowed to take place, in order to wash out all fragments and purulent debris. A plug of sterile gauze is now inserted into the sinus to control haemorrhage. The proximal portion of the sinus is also curetted until its lumen is perfectly clear, and fluid injected into the opened-up sinus flows freely through the cut end of the vein in the neck. The mastoid cavity is now cleansed and packed with gauze.

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[1] *Archives of Otology*, vol. xxxv. No. 3, 1906.

In a recent paper Voss[1] advocates the laying open of the thrombosed portion of the sinus throughout its entire extent, and the leaving of the clot *in situ* on account of the impossibility of completely removing all septic material, the danger of severe haemorrhage, and the possibility of injury to the brain with the curette.

His practice is to first ascertain the limits of the clot by puncture with a hypodermic needle. A longitudinal incision is then made along the centre of the clot and transverse cuts at either end. A strip of gauze is inserted in the direction of the bulb between the wall of the sinus and the bone so as to occlude its proximal end. The operation area is then packed, and the clot allowed to slowly disintegrate into the dressings.

The jugular bulb may be exposed by following the sinus downwards, or by completely removing the floor of the auditory meatus and tympanum.

Grunert's Operation.[2]—A complete post-aural operation is first performed, the groove of the sigmoid sinus opened, and all overhanging bone freely cut away. The original skin incision is then prolonged downwards beyond the tip of the mastoid process into the neck, and all soft structures drawn forcibly backwards and forwards so as to freely expose the mastoid apex, the digastric groove, and as much of the bone forming the base of the skull in the direction of the jugular foramen as possible. In drawing the anterior flap forwards, care must be taken not to tear the trunk of the facial nerve as it emerges from the stylo-mastoid foramen. The tip of the mastoid process is now removed, and the sigmoid sinus again exposed and traced as far inwards as possible as it runs more or less horizontally towards the jugular foramen. Great caution must now be exercised in removing the plate of bone leading up to the margin of the jugular foramen, a pair of pointed and strong bone forceps being used for the purpose. When all necessary bone has been removed, the jugular bulb will be seen freely exposed at the bottom of the wound. It should then be opened and the infected thrombus scooped out.

Piffl's Operation.[3]—Approaching the jugular bulb by removal of the floor of the auditory meatus and middle ear is held by the originator of this operation to be less dangerous to the integrity of the facial nerve, and also to be an easier procedure in those cases where the sinus lies far forwards and the jugular bulb is well developed.

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[1] *Zeitschr. f. Ohrenheilk.* vol. liii. p. 315.

[2] Grunert, *Archiv f. Ohrenheilk.*, 1902, vol. liii. p. 287.

[3] Piffl, *ibid.*, 1903, vol. lviii. p. 76.

The complete post-aural operation is first performed, and the apex of the mastoid process exposed by removal of the super-imposed soft tissues. The floor and anterior wall of the bony auditory meatus are now cut away as far as the Glaserian fissure. The apex of the mastoid process is then removed, care being taken to avoid injury to the facial nerve, which should be carefully drawn backwards with the soft tissues forming the posterior flap. The floor of the bony meatus is now removed by means of bone forceps as far inwards as the tympanum.

In performing this step of the operation it may be necessary to remove the styloid process in order to secure more room. This must be very carefully done, otherwise the facial nerve is likely to be injured. Once the styloid process has been removed the external jugular vein will be seen as it leaves the external jugular fossa. It should then be used as a guide, and followed upwards by removal of the bone which lies between it and the meato-tympanal floor, until the jugular bulb is finally exposed. During the performance of this step of the operation the greatest care must be taken in the removal of the surrounding bone for fear of injury to the external jugular vein.

If, after the exposure of the jugular bulb by one or other of the methods just described, it is considered advisable to expose the jugular vein in the neck, and remove it by dissection, the original skin incision should be continued downwards to meet the incisions already made for exposure and ligature of the vein in the neck. The vein is then seized with forceps and dissected, upwards and in the direction of the base of the skull. In so doing caution should be exercised, otherwise the great nerve trunks lying around it are likely to be injured.

After free exposure of the vein, jugular bulb, and sinus, an incision is made along the middle of their outer walls, the clot exposed, and removed by curette or forceps. The vein is now cut across as near to the bulb as possible and removed. Should haemorrhage take place from the inferior petrosal sinus or from the condylar veins, it should be arrested by packing.

After-Treatment.—In debilitated patients, and when the operation has been much prolonged in consequence of having to expose the bulb, a considerable amount of shock may result, necessitating the rectal injection of salines, the hypodermic injection of strychnia, or the administration of stimulants, *e.g.* champagne, brandy. If the jugular vein has been ligatured in the neck and its cut end brought out and stitched to the margins of the incision, daily irrigation from above downwards should be practised, until the washings become perfectly clear. The plug of gauze occluding the sinus at its torcular end should not be interfered with for five or six days, after which time it may be removed.

The antro-tympanic cavity should be cleansed daily with peroxide of hydrogen lotion and packed lightly with iodoform gauze.

In those cases in which the jugular vein has not been tied, the dressings, after a preliminary soaking with peroxide of hydrogen, should be removed from the sinus within forty-eight hours and with great care for fear of haemorrhage taking place. Should haemorrhage occur, fresh packing should be introduced at once, and left *in situ* for three or four days. The plug occluding the torcular end of the sinus should, however, be left undisturbed for at least a week.

On the other hand, should no haemorrhage take place after the withdrawal of the plug from the sinus, the wound may be treated as an ordinary granulating wound in bone, and dressed every second or third day.

Pyaemic abscesses which develop in the neck as the outcome of thrombosis of some minute vessel, or in joints or muscles as the result of transference of infective particles from the primary focus of disease, should be treated upon ordinary surgical principles.

In cases of severe septic intoxication the internal administration of quinine, turpentine, carbonate of ammonia, or intravenous injection of normal saline solution is called for.

The employment of an auto-vaccine or of a suitable serum is at times beneficial.

When no peri-phlebitis or inflammation of the cellular tissue of the neck is present, the wound in the neck, with the exception of a small opening at its upper end through which the distal portion of the jugular vein is brought out, may be closed by sutures.

It is advisable, however, when thrombosis of the vein is present, and the cellular tissue and glands in its immediate neighbourhood are infected, to leave the wound entirely open, merely packing it lightly with iodoform gauze.

CHAPTER XXXII

THE ANATOMY OF THE INTERNAL EAR

The Labyrinth.—*Anatomy.*—The internal ear or labyrinth consists of the highly specialised organs of hearing and equilibrium enclosed in a tortuous cavity of the petrous temporal bone.

It communicates, on the one hand, with the middle ear by means of two openings, the oval and round windows, and on the other with the brain by means of the auditory and vestibular nerves through the internal auditory meatus.

The bony labyrinth is lined with endosteum containing a fluid, the perilymph, in which is loosely supported a delicate but tortuous chamber, the membranous labyrinth. This in turn is filled with fluid, the endolymph, and encloses the cochlear and vestibular nerve terminals.

Although enclosed in an unyielding rigid canal these fluids are elastic, owing to the presence of membranous apertures communicating with the air, one of them carrying the ossicles which convey vibrations from the tympanic membrane.

The Osseous Labyrinth.—Notwithstanding the accepted fact that the petrous-temporal is one of the hardest bones in the body, there are portions of it in the immediate neighbourhood of the labyrinth which are extremely spongy, irregular in shape, and often the seat of serious inflammatory lesions. One such area lies anterior to the labyrinth and extends into the apex of the petrous element. Another and larger is external and posterior to it, merging into the diploic and pneumatic mastoid cells. It is indicated by the *sinus tympani*, of which it is practically a continuation.

This peculiarity is specially marked in early life, when the labyrinth appears as a sharply defined, dense, yet brittle structure surrounded by soft cancellous tissue.

In front and just below the cochlea the labyrinth is in close relation with the carotid canal; above it is the middle cranial fossa and the temporo-sphenoidal lobe; behind is the posterior cranial fossa and cerebellum; below, and somewhat posteriorly, is the vault of the jugular bulb; while a portion of the facial canal traverses its outer side.

This osseous canal consists of three parts:—(1) The vestibule or common sinus, into which open (2) three semicircular canals, and (3) a spiral tube or cochlea.

The *vestibule* is an irregular, ovoidal chamber, measuring 6 by 4 by 3 mm., and lies internally to the postero-superior part of the promontory. In its outer or tympanic wall is the *fenestra vestibuli*, or oval window, with the tympanic section of the facial canal just above. Antero-internally it is separated from the internal auditory meatus by its cribriform fundus pierced by vestibular nerves and vessels. Two well-marked depressions are here seen separated by a ridge, the *crista vestibuli*. The upper or *fovea elliptica* lodges the utricle, while the lower or *fovea spherica* lodges the saccule. There is also a small aperture in this wall, which is the opening of the *aqueductus vestibuli*.

The roof presents three openings—two for the ampullae of the superior and external semicircular canals, and one for the united return limbs of the superior and posterior semicircular canals.

Posteriorly is an opening for the return crus of the external semicircular canal, while the floor shows two openings, one for the ampulla of the posterior semicircular canal, and one for the large vestibular aperture of the cochlea overhung by the lamina spiralis.

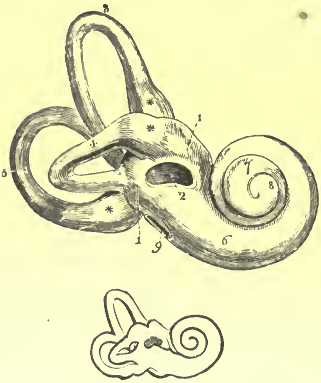

Fig. 214.—Right osseous labyrinth, magnified $2\frac{1}{2}$ times. The figure below is natural size. 1, Vestibule; 2, fenestra ovalis; 3, superior semicircular canal; 4, external semicircular canal; 5, posterior semicircular canal; * * *, their ampullae; 6, 7, 8, turns of cochlea; 9, fenestra rotunda. (From Quain's *Anatomy*, vol. iii. pt. iii.)

In relation with the tympanum the floor corresponds with the top of the fossula rotunda.

The *cochlea* (Fig. 214) is a stunted cone, having its base turned towards the internal auditory meatus and its apex towards the ostium tympanicum of the Eustachian tube about the level of the cochleariform process. It consists of a spiral canal of two and three-quarter turns, winding round a central column or modiolus. This canal is about 33 mm. in length and 2 mm. in diameter at its commencement or widest part, whence it gradually diminishes to the cupola.

Its first turn bulges into the tympanic cavity, and forms the promontory, which is pierced posteriorly by the *fenestra cochleae* or round window.

Each turn is partially divided by a projection, the *lamina spiralis ossea*. The basal portion, or *scala tympani*, commences at the fenestra tympani, near which is the opening of the *aqueductus cochleae*. The other portion, or *scala vestibuli*, is somewhat the smaller of the two at its commencement, but in its course it becomes relatively the larger.

The modiolus or axis of the cochlea forms part of the fundus of the internal auditory meatus as the cochlear fossula, containing foramina for transmitting the fibres of the cochlear nerve. The centre of the modiolus is spongy and canalised for nerve bundles and a vessel.

Of the three *semicircular canals*, the *external* or horizontal is the one most easily reached from the antro-tympanic chamber, being situated near the *aditus ad antrum*, and forming the external arcuate eminence, having between its outer limb and the oval window a portion of the facial canal, a relation to be remembered when dealing with the "bridge" during the radical operation. Its ampulla is situated just above the fenestra vestibuli and the facial aqueduct, while its return end opens in the posterior vestibular wall. It is the shortest canal.

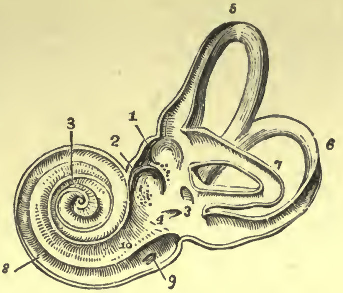

Fig. 215.—Interior of left labyrinth. 1, Fovea hemielliptica; 2, fovea hemispherica; 3, common return of superior and posterior semicircular canals; 4, aqueductus vestibuli; 5, superior semicircular canal; 6, posterior semicircular canal; 7, external semicircular canal; 8, scala tympani; 9, aqueductus cochleae; 10, scala vestibuli.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

The *superior* canal is a prominent feature in the upper aspect of the petrous bone, especially in early life, when the subarcuate fossa is easily seen extending under its arch towards the mastoid antrum. In the adult this fossa becomes filled with cancellous bone, and is often the seat of caries. The canal is about 19 mm. in length, and its ampulla opens into the vestibular roof.

The *posterior* canal is the least accessible and visible even in infants. Its arch embraces the vestibular aqueduct, while its lower limb lies in the roof of the jugular fossa internally and posteriorly to the *sinus tympanicus*. The posterior is the longest of the semicircular canals (22 mm.). Its ampulla opens at the back part of the vestibular floor, while its return end unites with the superior to pierce the roof.

The *fenestra vestibuli* lies at the bottom of the *pelvis ovalis*, whose upper wall contains the facial canal, so limiting opening in that direction.

The *fossula rotunda* leading to the *fenestra tympani*, is often partially hidden by the promontory, and may be still further obscured when the tympanic floor is pushed upwards by a high jugular vault.

The *internal auditory meatus* is a trumpet-shaped portion of very compact bone about 8 mm. in depth. It possesses such important relations to the labyrinth, of which it is apparently a direct continuation, as to demand special reference. At its fundus is a reniform depression unequally divided by a ridge, the *falciform crest* (Fig. 218). The upper fossa presents apertures for the facial nerve and for the vestibular branches of the eighth nerve to the utricle and the ampullae of the superior and external semicircular canals; the lower or *fossula cochleae* contains the *foramen centrale* for transmitting fibres to the apical turn of the cochlear tube, the *tractus spiralis foraminulentus* for fibres to the lower turns of the tube, one going to the saccule, and the *foramen singulare* for conveying the nerve to the posterior semicircular canal.

There are two important channels connected with the labyrinth, which, although chiefly of vestigial interest in the adult, are often large in early life. They may even persist and become channels for the conveyance of infection at all ages. The *aqueductus vestibuli*, which transmits a small vein and the ductus endolymphaticus, starts near the fovea elliptica in the vestibule and opens on the posterior surface of the petrous bone as a flattened slit-like aperture behind the floccular fossa, having above it the posterior semicircular canal.

The *aqueductus cochleae* extends from the first turn of the cochlea near the round window, downwards and inwards to a somewhat triangular-shaped aperture in front of the jugular fossa and behind the carotid canal. It transmits two small veins, one to the inferior petrosal sinus and one to the internal jugular. It also carries the remains of the ductus perilymphaticus which connects the perilymph of the scala tympani with the subarachnoid space and the deep lymphatics.

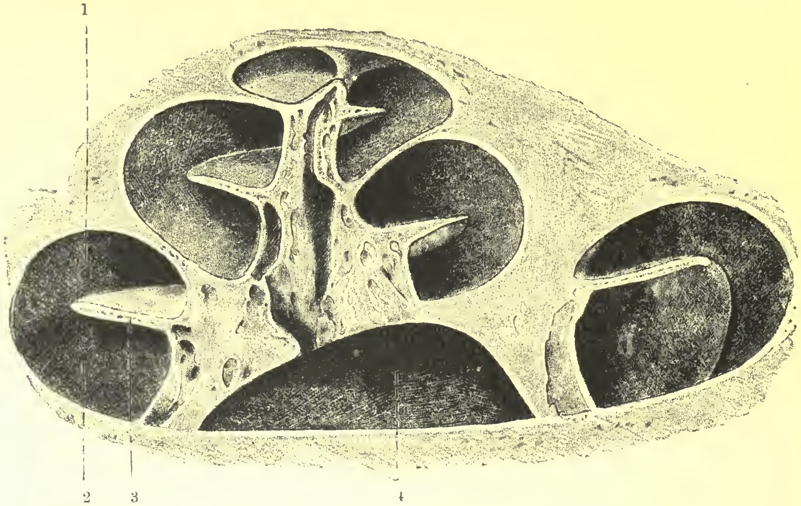

Fig. 216.—Osseous cochlea. 1, Scala vestibuli; 2, scala tympani; 3, lamina spiralis; 4, fovea cochleae of internal auditory meatus.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

The whole of the osseous labyrinth is composed of dense ivory bone without any cancellous spaces, in striking contrast with much of that surrounding it, which is diploetic.

Arteries of the Labyrinth.—The internal auditory artery, derived from the basilar, enters by the meatus internus and divides into branches for the vestibule and cochlea. The vestibular artery supplies the endosteum and the membranous labyrinth. The cochlear is broken up into twelve branches which pierce small canals in the modiolus to form a glomerular plexus between the cochlear turns from which minute arterioles are sent to the stria vascularis and the endosteum of the scalae.

The bony cochlea also receives a small branch from the stylomastoid branch of the occipital artery through the fenestra cochleae. Other minute branches are derived from meningeal vessels accompanying prolongations of the dura mater. Minute vessels from the tympanic cavity also supply the bony labyrinth, but do not anastomose with those of the membranous labyrinth.

Venous blood is collected into the internal auditory vein which opens into the inferior petrosal sinus. Other vessels pass to the same sinus along the aqueductus cochleae and vestibuli. A special vein from the lower turn of the cochlear tube reaches the internal jugular vein by the aqueductus cochleae.

The Membranous Labyrinth represents the original otic vesicle (Fig. 219). It is a closed irregular chamber lined with epithelium containing endolymph. It receives the terminals of the auditory and vestibular nerves, and is separated from the endosteum of the bony labyrinth by perilymph, except at the points of entrance of the nerves and on the convex border of the canals where membranous labyrinth and endosteum blend.

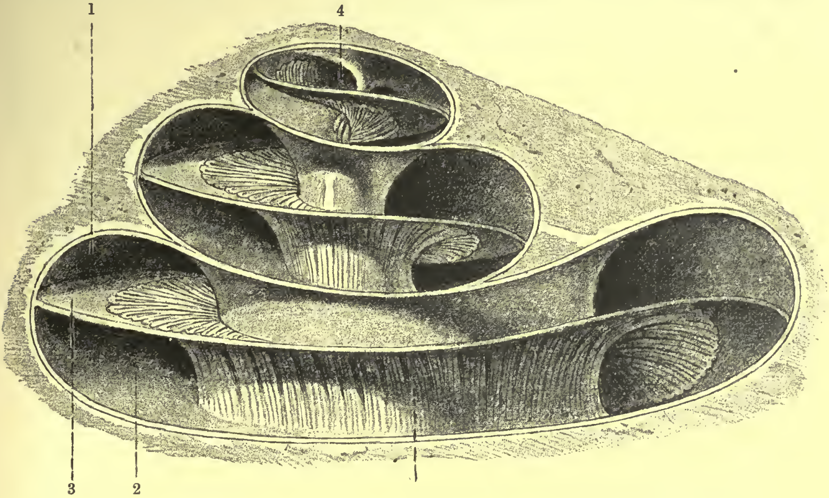

FIG. 217.—Diagram of the osseous cochlea. 1, Scala vestibuli; 2, scala tympani; 3, lamina spiralis; 4. helicotrema.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

Within the osseous vestibule are two sacs, one the *utricle* which belongs to the semicircular canals, the other the *saccule* which belongs to the cochlea. Although apparently separated they are connected indirectly through the *ductus endolymphaticus*, and are part of the membranous labyrinth.

The Utricle or common sinus rests chiefly in the fovea elliptica. It is marked by three ampullae, those for the superior and external semicircular canals opening in the roof of the recess, while that for the posterior opens into the sinus posteriorly; between them are the return tubes of the superior and posterior semicircular canals in one common canal, and that of the external semicircular canal separately.

Further, a fine canal, the *canalis utriculo-saccularis*, joins with another from the saccule to form the *ductus endolymphaticus.* The utricle contains the *macula acustica*; also *otoliths* or calcareous masses of crystalline carbonate of lime which are less marked in man than in some of the lower animals. Otoliths do not occur in the cochlea, and have been interpreted as vestigial relics.

It may be again mentioned that the bony labyrinth is completely lined by a delicate fibro-vascular capsule, the endosteum, from which delicate bands pass to the walls of the membranous labyrinth, where they are separated by intervening perilymph, but merge closely with its outer layers where in direct contact.

The walls of the membranous labyrinth consist of three distinct layers which, although well defined in the case of the semicircular canals, the utricle, and saccule, in the cochlear tube are more highly differentiated.

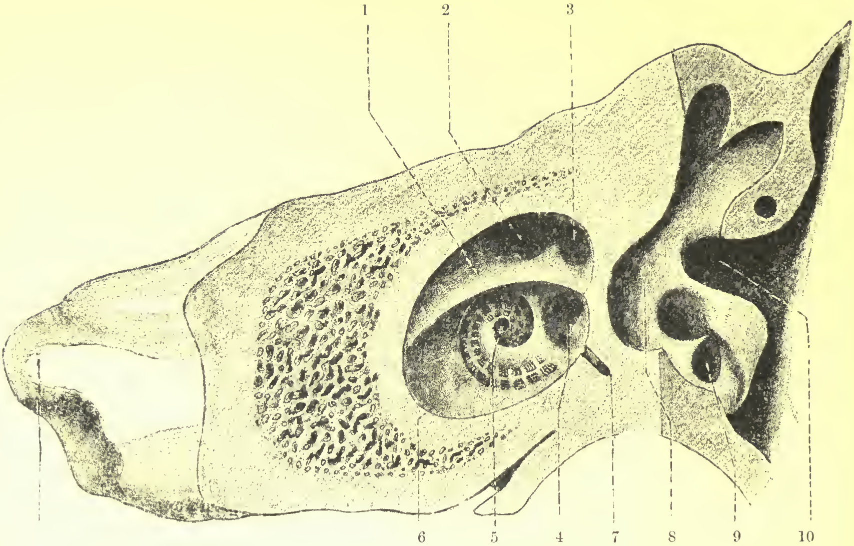

FIG. 218.—Section of temporal bone to show fossa of the internal auditory meatus. 1, Falciform ridge; 2, facial canal; 3, vestibular nerves; 4, nerves to saccule; 5, central canal of modiolus; 6, spiral tract; 7, foramen singulare; 8, vestibule; 9, scala tympani; 10, fossa ovalis.
(From Quain's *Anatomy*, vol. iii. pt. iii.)

The *outer* or fibro-vascular layer consists of white fibres similar to, and continuous with those of the endosteum, and contains a fine capillary network of arterioles and pigment cells. The *middle* or *tunica propria* is a clear, non-vascular, membranous, almost hyaline stratum, easily recognised as a continuous structure throughout the whole tube, and occasionally projecting as small papillary elevations into the lumen.

The *internal* or epithelial layer is a single layer of cells with prominent oval nuclei. In man they are flattened, but in birds they are columnar.

In the ampullae, as also in the utricle and saccule, local differentiation and specialisation of this layer is seen in the cristae and the maculae. The tunica propria is here much thickened, and projects into the cavity conveying the nerve fibres which pass to terminate in the modified epithelium. This consists of two kinds:—(*a*) elongated columnar or supporting cells (fibre-cells of Retzius) which rest on a hyaline covering to the basilar membrane, and at their free surface are said to be attached to a cuticular structure which encloses the ends of the (*b*) *hair cells* which are placed between them but do not reach the basilar membrane. Around the latter a minute plexus of axis cylinders is found from which filaments are probably distributed to either the nucleus or cytoplasm of the hair cell.

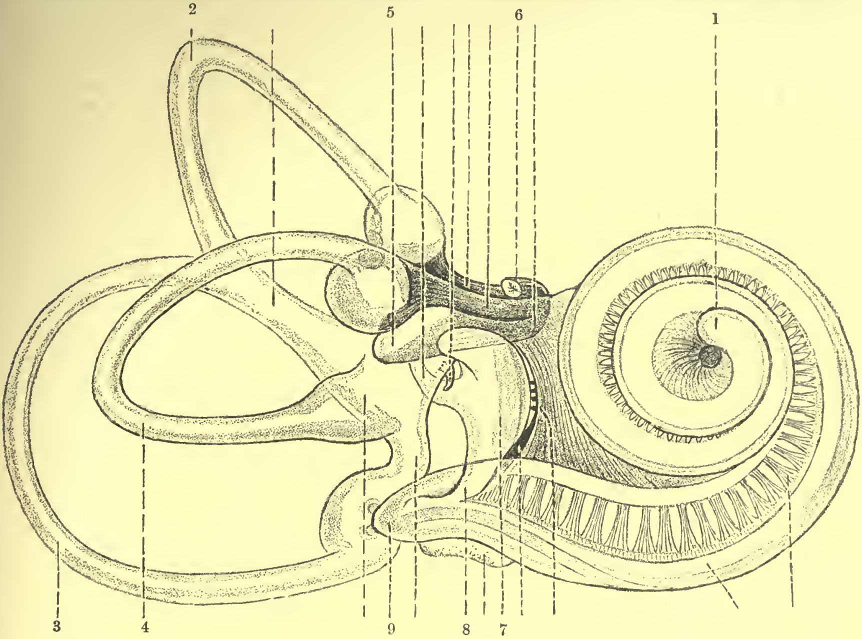

FIG. 219.—Diagram of membranous labyrinth (antero-lateral aspect). 1, Lagena; 2, superior semicircular canal; 3, posterior semicircular canal; 4, external semicircular canal; 5, recessus utriculi; 6, facial nerve; 7, saccule; 8, canalis reuniens; 9, vestibular end of cochlear canal. (From Quain's *Anatomy*, vol. iii. pt. iii.)

The Cochlear Tube differs from the rest of the membranous labyrinth chiefly in its shape and its epithelial lining. It occupies the central of the three chambers seen on section of a cochlea, being bounded above by Reissner's membrane, below by the *membrana basilaris*, at its base by the *ligamentum spirale*, and apically by the limbus (Fig. 221). It is about 35 mm. in length, and consists of about $2\frac{3}{4}$ turns, the apical being incomplete. Above it is the *scala vestibuli*, while below is the *scala tympani*, two tracts containing perilymph, which accompany its spiral turns and meet at a point in the apex called the *helicotrema*. The cavity of the cochlea or *ductus cochlearis* terminates at the apex in a blind extremity, the *lagena*, which is fixed to the walls of the bony cupola and partly bounds the helicotrema. Its basal end fits into the angle formed by the osseous spiral lamina in front of the vestibular floor. Near this end it gives off a small canal, the *canalis reuniens*, to the saccule, which in turn gives off another uniting with one from the utricle, which uniting form the *ductus endolymphaticus*.

Upon the floor of the cochlear canal is placed the special terminal of the auditory nerve, the organ of Corti. This floor is formed by the limbus (which is continuous with the osseous spiral lamina) and the basilar membrane.

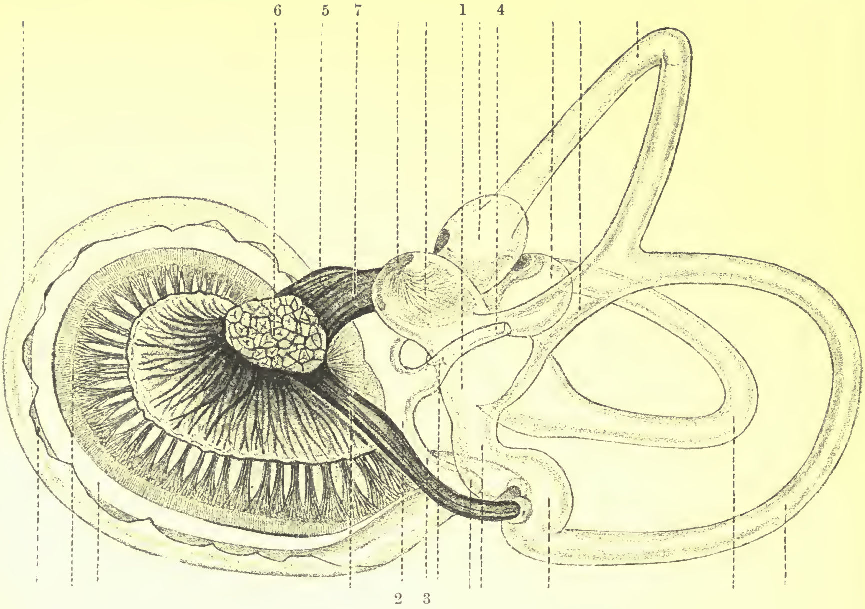

Fig. 220.—Diagram of membranous labyrinth (postero-mesial aspect). 1, Utricle; 2, saccule; 3, canalis reuniens; 4, ductus endolymphaticus; 5, facial nerve; 6, cochlear nerve; 7, vestibular nerve. (From Quain's *Anatomy*, vol. iii. pt. iii.)

The Limbus is a fibrillated structure presenting an upper lip, or *labium vestibulare*, a lower, or *labium tympanicum*, and a sulcus, or spiral groove. The lower lip is continued outwards to the basilar membrane. Near its termination it is perforated by about 4000 apertures for the passage of the auditory nerve bundles as they pass from the spiral ganglia to the auditory epithelium.

The upper lip is deeply channelled, the furrows extending along its upper surface as far as Reissner's membrane. At the extreme edge of this lip the columnar epithelium becomes so flattened as to be scarcely visible, but towards the sulcus and Reissner's membrane it again becomes well defined, assuming a cubical shape. From this lip extends the *membrana tectoria.*

The *basilar membrane* connects the lower lip of the limbus with the spiral ligament of the endosteum, into which it spreads by radiating fibres and cells. It increases in breadth from the base to the apex of the cochlear canal at the expense of the lamina spiralis which diminishes proportionally. It presents two zones: an inner or *zona arcuata* which carries the organ of Corti, and an outer or *zona pectinata* which is thicker and more fibrous. It is composed of a homogeneous matrix containing nuclei, pierced by straight elastic fibres radiating from the spiral lamina to the spiral ligament into which they spread out. Retzius gives their number as being 24,000.

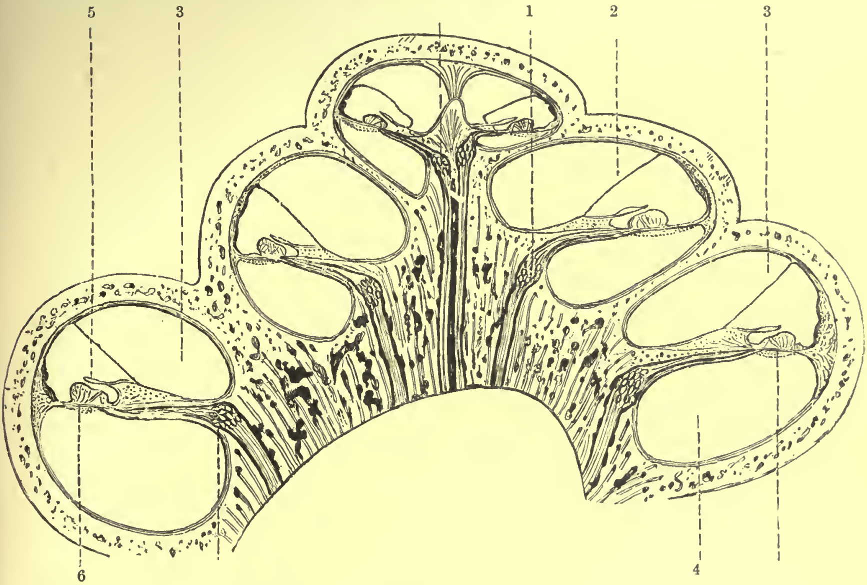

FIG. 221.—Diagrammatic section through middle of cochlea (osseous and membranous). 1, Ganglion spirale; 2, Reissner's membrane; 3, scala vestibuli; 4, scala tympani; 5, membrana tectoria; 6, organ of Corti.

(From Quain's *Anatomy*, vol. iii. pt. iii.)

The under surface of this layer is covered by connective tissue fibres arranged parallel to the spiral canal, and consequently across the direction of the elastic fibres. Mixed with them are fusiform connective tissue cells continuous with the endosteum, and minute blood-vessels chiefly found in its inner zone, one vessel being specially known as the *vas spirale* from its longitudinal direction.

Reissner's Membrane is composed of very fine connective tissue fibres covered on its vestibular side with large flattened endothelial plates, and on its cochlear with smaller flattened epithelial cells continuous with those of the limbus.

The outer wall of the cochlear canal is formed by a thickening of the endosteum, covered by columnar epithelium, often containing pigment. Between the spiral ligament and the attachment of Reissner's membrane is a slight projection formed by a vessel, the *vas prominens.*

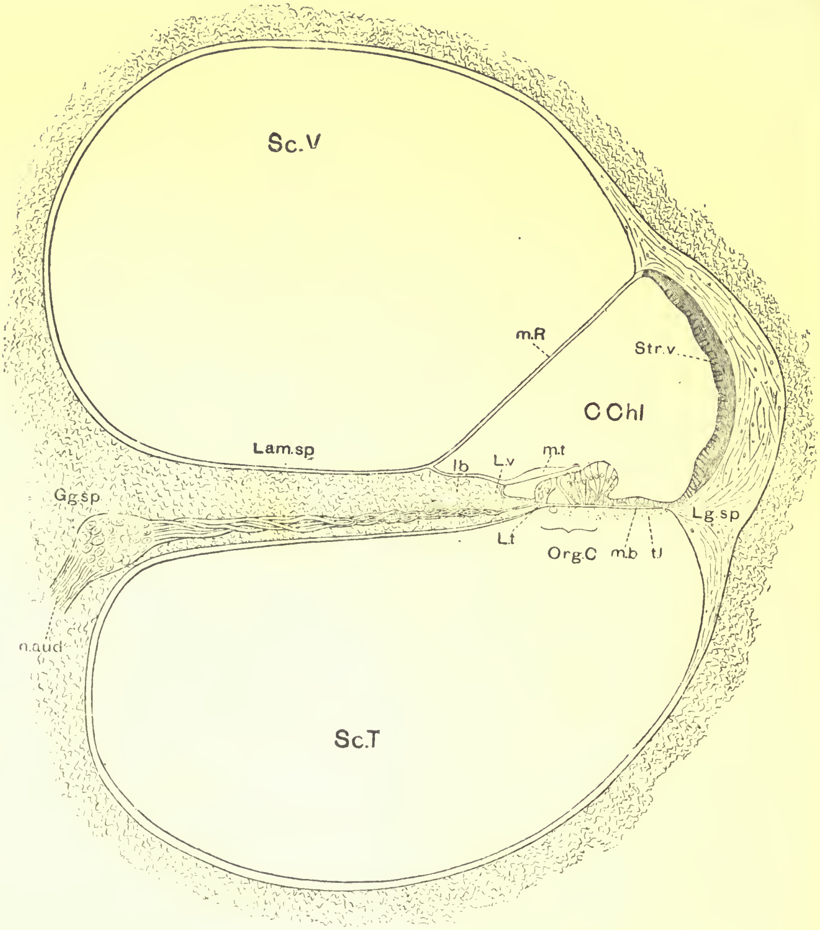

Fig. 222.—Diagram of a spiral turn of the cochlea (osseous and membranous). (From Quain's *Anatomy*, vol. iii. pt. iii.)

Between this and Reissner's membrane the endosteum is very vascular and pigmented, constituting the *stria vascularis.* The hyaline basement membrane is here well marked, extending into the spiral ligament, which in turn merges into the basilar membrane.

The Organ of Corti is a very highly specialised portion of the epithelium lining the otic vesicle. It rests upon the *zona arcuata* of the basilar membrane, and like other special sensory terminals consists essentially of two kinds of cells—special or ciliated, and supporting. The latter are extremely various in size, shape, and arrangement. A central group, whose feet rest upon the basilar membrane, constitute the inner and outer rods of Corti. These are inclined towards one another so as to form a long continuous arch or tunnel along the cochlear canal. Resting on these rods are *hair cells*, one row on the inner, and three or four rows on the outer rods. Embracing the hairlets of the outer ones only is a cuticular membrane known as the *lamina reticularis.* Passing either inwards towards the limbus or outwards towards the ligamentum spirale these cells are replaced by epithelium more simple in type becoming cubical in shape and bearing no cilia.

The Rods of Corti possess nucleated wedge-shaped cells at their feet where attached to the basilar membrane (basilar cells). The inner rods are said to be more numerous than the outer, and more closely applied to each other.

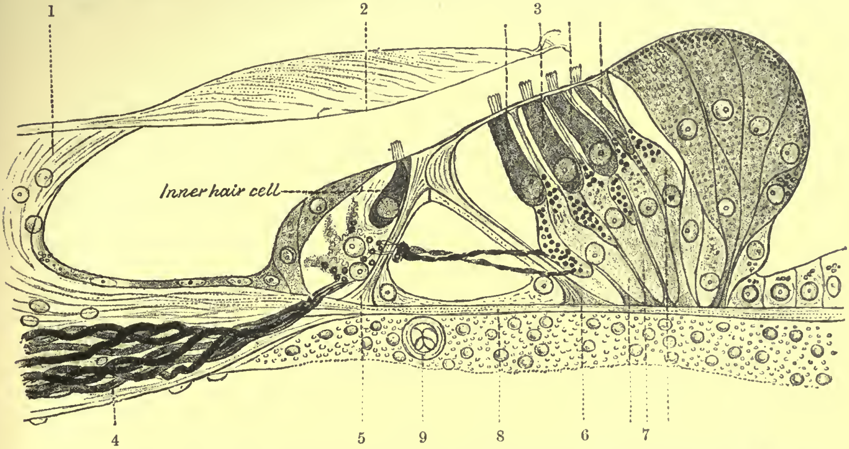

FIG. 223.—Section through the organ of Corti. 1, Limbus; 2, membrana tectoria; 3, outer hair cells; 4, inner hair cells; 5, inner rod; 6, outer rod; 7, cells of Deiters; 8, basilar membrane; 9, vas spirale.

(From Quain's *Anatomy*, vol. iii. pt. iii.)

The *inner hair cells*, 3500 in number, resemble nucleated columnar epithelium, tapering to the lower lip of the limbus. Between them and the sulcus is a series of gradually shortening nucleated plain epithelial cells.

The *outer hair cells* are cylindrical above, but flattened below. Like the inner ones each carries about twenty hairlets which project through the lamina reticularis.

Beneath the hair cells are the cells of Deiters, which rest upon the basilar membrane, and send processes upwards to the lamina reticularis —the phalangeal processes.

Extending over the organ of Corti, as far as the limits of the outer hair cells, is a delicate distinctly striated structure, the tectorial membrane. It arises apparently from the upper surface of the limbus near the attachment of Reissner's membrane, and tapers to a thin film at its periphery.

From the fact that it is confined to the region of the hair cells, from its structure, and from a study of its autogeny, it is suggested that it merely represents the remains of long filaments which once belonged to the hair cells and stretched from them as a "hair band" on to the limbus.

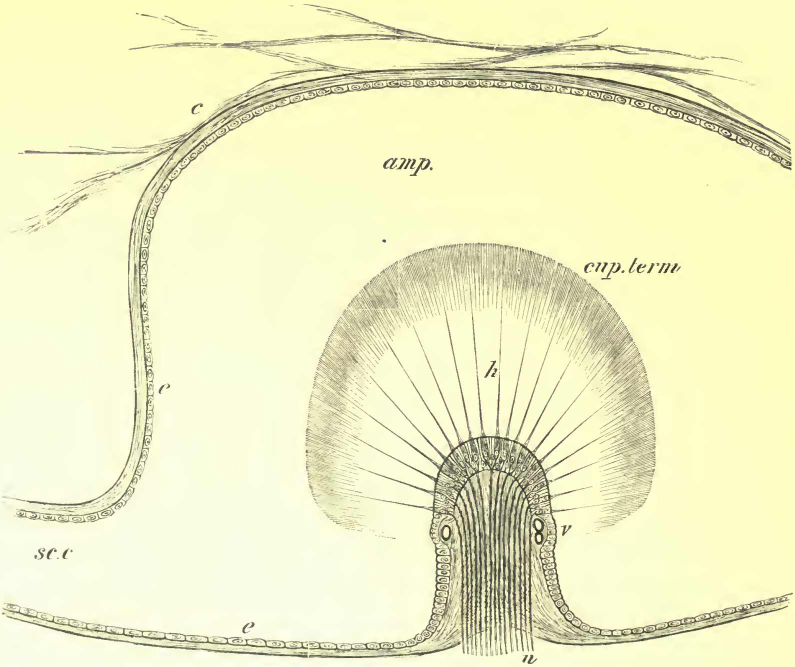

FIG. 224.—Diagram of crista acustica in an ampulla. *h*, Hair cells; *c*, connective tissue attachment of ampulla traversing the perilymph; *amp.*, endolymph. (From Quain's *Anatomy*, vol. iii. pt. iii.)

Distribution of the Cochlear and Vestibular Nerves.—The *cochlear* branches from the inferior division of the eighth nerve pass through the fundus of the internal auditory meatus in its lower fovea, at the base of the cochlea, in groups which pierce the spiral furrow through minute foramina. They travel in bony canals through the modiolus, and then radiate outwards between the plates of the bony spiral lamina to the *ganglion spirale*, one set passing into the central canal of the modiolus for the special supply of the last half-cochlear turn. The cells of the *ganglion spirale* are bipolar, there being one to each fibre. Thence the fibres assume a plexiform arrangement, and passing through the bony lamina eventually pierce the lower lip of the limbus, losing their medullary sheaths to terminate in or around the hair cells.

The *vestibular* branches are chiefly derived from the superior division of the eighth nerve in the internal auditory meatus which passes above the crest to the utricle and ampulla of the superior and external semicircular canals.

The saccular branch is derived from the lower or cochlear division, which enters the vestibule by foramina in the *fovea spherica*, while that to the posterior semicircular canal enters by the *foramen singulare.* It is interesting to note that, unlike the cochlear division, these nerves are ganglionated in the internal auditory meatus with the exception of that going to the posterior semicircular canal which has a ganglion near its ending in the ampulla.

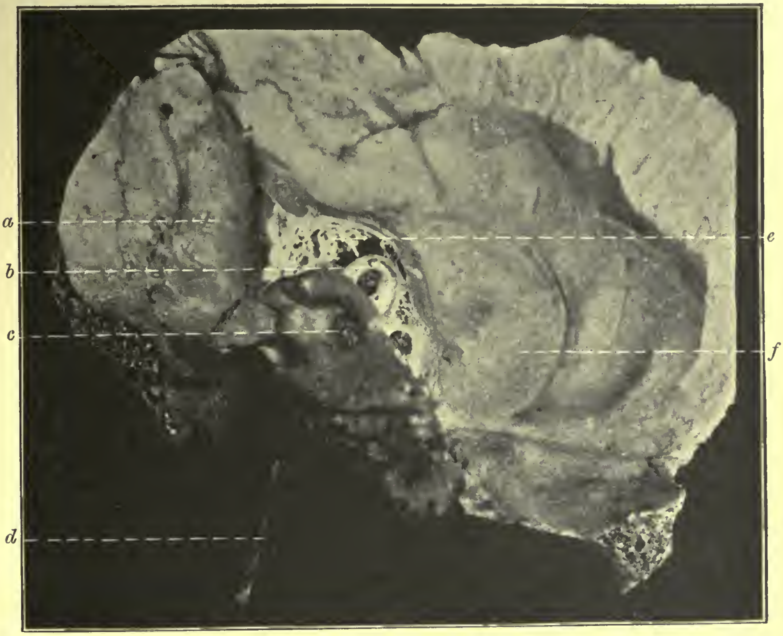

FIG. 225.—Internal surface of temporal bone showing, *a*, groove for sigmoid sinus; *b*, superior semicircular canal; *c*, internal auditory meatus; *d*, styloid process; *e*, middle-ear cleft; *f*, squamous portion of temporal bone.

THE MODE OF CONTINUITY OF THE AUDITORY SENSE EPITHELIUM WITH THE AUDITORY NUCLEI IN THE HIND BRAIN

The embryology of the auditory nerve in vertebrates, which has been recently studied by Cameron and Milligan,[1] is found to possess a direct bearing on the mode of continuity of the auditory sense epithelium with the auditory nuclei in the hind brain. The result of their researches shows that the auditory end organ is brought into intimate anatomical connection with the hind brain during its early developmental stages by means of a nucleated mass of cytoplasm, to which the term *auditory syncytium* was applied. The latter becomes later on transformed into the auditory nerve, the breaking up of which into its divisions is a necessary accompaniment of the differentiation of the wall of the otic vesicle into its various sense epithelium patches. Thus each patch bears off its quotum of the auditory syncytium with which it was originally in such intimate continuity. The cochlear and vestibular portions of the auditory nerve are therefore not its fundamental divisions. The latter must obviously correspond in number to the sense epithelium patches in the membranous labyrinth which in higher mammals, including man, number six, consisting of one for each semicircular canal, one for the utricle, one for the saccule, and one for the cochlea. The number is even greater in the lower vertebrate classes, there being as many as eight in birds and amphibians, and seven in higher fishes.

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[1] "The Development of the Auditory Nerve in Vertebrates," *Journ. of Anatomy*, vol. xliv., 1910.

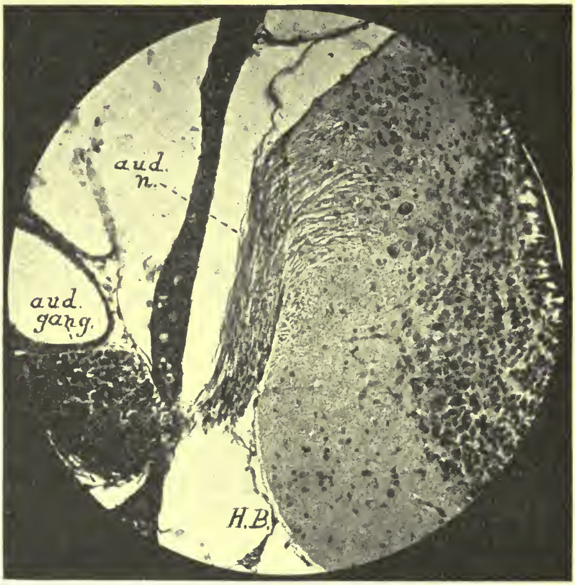

FIG. 226.—Direct anatomical continuity of the auditory nerve fibres with the cells of the auditory nucleus in the hind brain (frog).
(From Cameron and Milligan's article, *Journal of Anatomy and Physiology*, vol. xliv.)

Three types of neuroblast may be identified in the auditory syncytium. The term α-neuroblast indicates those existing during the early stages, the β- and γ-neuroblasts being rather elaborations of the α type and representing distinct phases in the octogeny of the nerve-cell. The γ-neuroblasts were found to make their appearance in three situations, namely, in the hind brain, in the wall of the otic vesicle, and in the syncytial tract midway between these points. They obviously give rise to the highly evolved cells composing the various auditory nuclei in the hind brain, the auditory sense epithelium, the spiral ganglia, and the ganglia of Scarpa. The β-neuroblasts become the neurilemma cells of the auditory nerve fibres, and in this relation it is important to note that the cytoplasm of the auditory syncytium is undifferentiated during its early stages, and represents the *nascent* or *achromatic* phase of the auditory nerve axons. Very soon, however, this material becomes fibrillated longitudinally in a definite manner to form one continuous tract of neuro-fibrillae, uniting the sense epithelium with the cells in the hind brain. This represents the *mature* or *chromatised* phase of the auditory nerve axons. These fibrillae could be traced from the γ-neuroblasts in the middle of the syncytial tract (Fig. 227), centrally to the neuro-fibrillae in the cells of the hind brain (Fig. 226), and peripherally to the neuro-fibrillae in the sense epithelium cells (Fig. 229).

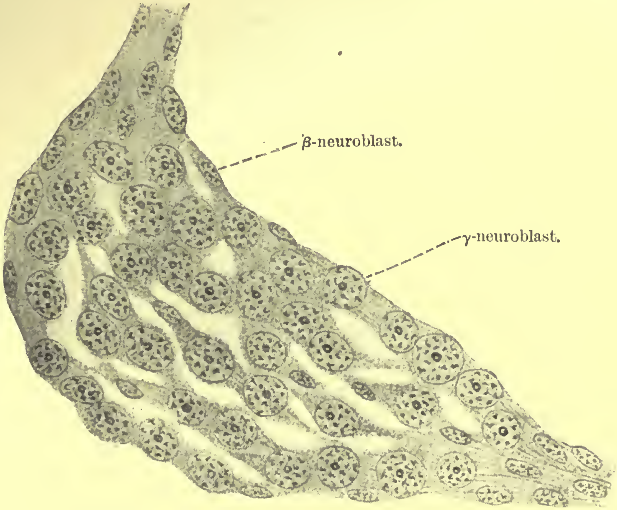

FIG. 227.—The fibrillation of the intermediate portion of the auditory syncytium in a 13-mm. frog embryo. Note also the differentiation of the β- and γ-neuroblasts.
(From Cameron and Milligan's article, *Journal of Anatomy and Physiology*, vol. xliv.)

It is evident from the foregoing statement that the auditory nerve axons are not unicellular outgrowths, but are produced by a fibrillation of achromatic material representing several cell elements of the auditory syncytium.

That is to say, they are multicellular in origin. Further, each axon is probably represented at first by single fibrillae, the mature or fully developed structure being merely an aggregation of the latter. It follows from this that the unit of nerve structure is not the axon, but the fibrilla.

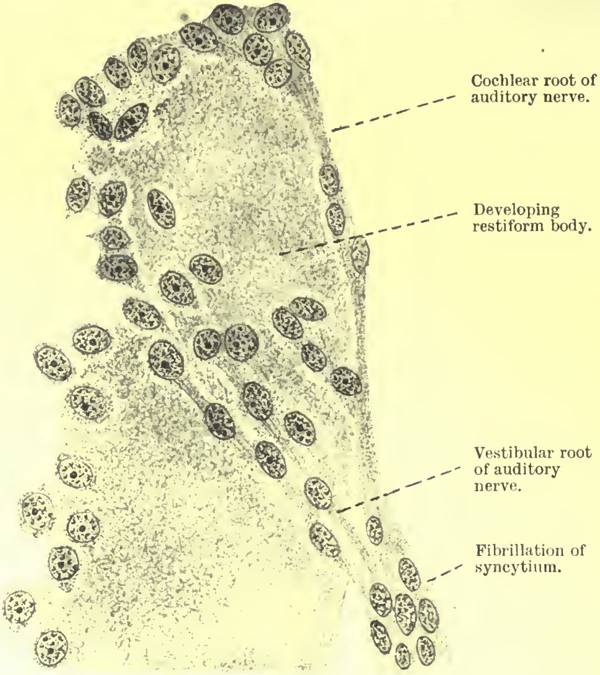
Cochlear root of auditory nerve.
Developing restiform body.
Vestibular root of auditory nerve.
Fibrillation of syncytium.

FIG. 228.—Fibrillation of the central end of the auditory syncytium in a 13-mm. frog embryo. (From Cameron and Milligan's article, *Journal of Anatomy and Physiology*, vol. xliv.)

Those portions of the auditory syncytium next to the hind brain and otic vesicle become attenuated and quite freed from β-neuroblasts

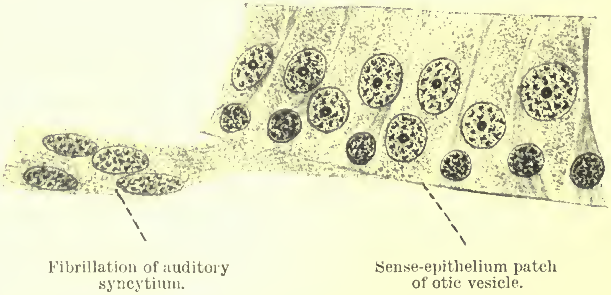
Fibrillation of auditory syncytium.
Sense-epithelium patch of otic vesicle.

FIG. 229.—Fibrillation of the peripheral end of the auditory syncytium in a 13-mm. frog embryo. (From Cameron and Milligan's article, *Journal of Anatomy and Physiology*, vol. xliv.)

(Figs. 228 and 229). By the time fibrillation occurs the calibre at this situation has become decidedly less than that of the remainder of the syncytium. The portions of the cytoplasm in these regions which do not become differentiated into fibrils persist as the medullary sheaths. However, since there are no β-neuroblasts left in these segments of the nerve tracts there can be no development of the neurilemma sheath (*vide supra*). This explains why in the adult the latter terminates just before the auditory nerve fibres enter the hind brain or the sense epithelium. Owing to this deficiency in the covering of the fibres it is obvious that these segments must constitute weak spots in the nerve trunk. In this relationship it is important to note that Orr and Rows[1] have demonstrated how, in certain chronic nervous affections, degeneration commences in the sensory roots immediately before they enter the central nervous system, that is, exactly at the point where they lose their neurilemma sheath. These observers have likewise found that after the implantation of celluloid capsules containing toxins in various parts of the body the resulting degeneration of the sensory fibres invariably started at this situation. They have accordingly termed this the "vulnerable point," and there can be no doubt that it is so considered from a developmental as well as from an experimental and clinical standpoint.

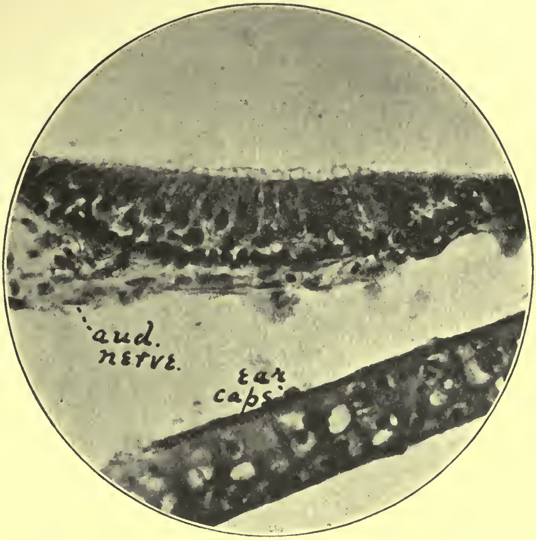

FIG. 230.—The auditory sense epithelium (frog), showing short thin hairs, large nuclei of sense epithelium, and small nuclei of cells of Deiters.

It has been shown already that the auditory syncytium, the γ-neuroblasts in the hind brain, the sense epithelium, and the γ-neuroblasts in the middle of the syncytial tract become fibrillated simultaneously. The resulting neuro-fibrillae thus form one continuous bond of union between the sense epithelium and the hind brain. Thus the intimate association which the end organ bears to the hind brain during its early stages through the medium of the auditory syncytium never really becomes severed.

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[1] "A Clinical and Experimental Investigation into the Lymphogenous Origin of Toxic Infection of the Central Nervous System," *Review Neurol. and Psych.*, May 1907.

The theory of continuity by synapse should therefore be abandoned in favour of the theory of a direct anatomical continuity of tissue.

CHAPTER XXXIII

DISEASES OF THE LABYRINTH

Foreword.—In the present state of our knowledge it must be at once admitted that but few purely primary or intrinsic diseases of the labyrinth are recognised. Severe secondary involvement from the middle ear or from the cranial cavity is, however, more common, but even this form is exceptional in view of the large number of cases of antro-tympanic disease which are associated with only transient symptoms of labyrinthine disturbance.

Doubtless, increased facilities for observation afforded by a more thorough surgical technique, more precise methods of diagnosis, and a closer study of its morbid anatomy, will ere long necessitate a readjustment of our views regarding this somewhat inaccessible organ. At present, however, one is inclined to regard labyrinthine phenomena—like retinal—as being chiefly symptomatic rather than concrete. From its almost claustral situation one is inclined to assume that the labyrinth is specially immune from injury and disease, yet this isolation may in some respects be a disadvantage since the channels by which it may be attacked are so hidden from view and so difficult of access for treatment.

Although functionally part of the organ of hearing it is developmentally, anatomically, physiologically, and clinically almost a separate entity, for, as already shown, it is protected by specially dense osseous walls, and is, on the one hand, in close relationship with the antro-tympanic cavity by the fenestrae and vascular canals, and on the other with the cranial cavity by various foramina and the internal auditory meatus. In addition, there are two supplementary canals, the aqueducts of the cochlea and vestibule, but the most vulnerable points are perhaps the fenestrae.

To fully realise the difficulties in dealing with pathological phenomena too much emphasis cannot be laid upon the fact that the labyrinth has not only a special vascular supply, but is controlled also by an entirely different vascular nervous mechanism from that of the middle ear. The labyrinth is, in fact, an outlying part of the brain, sharing with it its blood-supply and nervous mechanism quite apart from the rest of the body and adjacent structures. It is therefore not directly affected by vaso-motor influences visible in the auricle.

As already mentioned, the membranous labyrinth receives its blood-supply from the basilar artery through its internal auditory branch. This vessel is distributed to the membranous canals and adjacent endosteum forming no anastomosis whatever with the antro-tympanic vessels.[1] The venous blood is returned by the internal auditory veins to the inferior petrosal sinus, and by small veins through the aqueductus cochleae and vestibuli to the same sinus and internal jugular vein. Thus, as pointed out by Dundas Grant, pressure upon the vertebral artery will afford differentiation between phenomena of labyrinthine and those of tympanic origin.

Whatever may be the exact nature of the vaso-motor control of the brain, there is every reason to assume that it also controls the labyrinthine mechanism, and is entirely separate from that of the adjacent external and middle ears. Further, like the brain, the labyrinth is, in spite of its blood-supply passing through a double set of osseous constrictions, exceptionally sensitive to variations in the general blood-pressure.

Nystagmus.—The association of ocular movements with labyrinthine disturbance has long been the subject of observation, and has become of such great interest and importance in otology that a few words will be devoted to those ocular movements specially known as vestibular.

In 1895 Crum Brown demonstrated the intimate connection between ocular and ampullary phenomena by means of a rotatory lighthouse table.

Later Bárány has extended the observations and applied them clinically in such a way as to afford most reliable and valuable evidence of the condition of the vestibular portion of the internal ear.

Nystagmus may be induced for diagnostic purposes in three ways: 1. Rotation; 2. Caloric reaction; 3. Pressure tests.

Rotation may be effected by rotating the patient on a carefully adjusted revolving table or chair, or by suspension in a swing.

The caloric test is applied by syringing warm or cold water into the external auditory meatus. This sets up certain changes in the vestibular apparatus and so causes movements in the eyeballs.

The pressure test is usually made with Siegle's speculum.

In the rotation test nystagmus occurs during and after the revolution. Under ordinary circumstances early nystagmus cannot be observed, it is the *after* nystagmus which is of interest. Its direction is *towards the side* from which the patient was rotated.

By inclining the head 90° towards the right shoulder and then rotating, vertical nystagmus is induced; *if bent* forwards or backwards, rotatory nystagmus follows to the right or left according to the direction of rotation.

The duration of *after* nystagmus which follows, from right to left, averages 41 seconds, while from left to right it is 30 seconds.

Experience proves that the most suitable rate of rotation is ten turns in 20 seconds.

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[1] *Quain*, vol. iii. part 2, p. 108.

Bárány's interpretation of the *caloric* test is that the varying temperature sets up certain sensations in the ampullae, and does not act by causing variations of endolymph pressure.

His results are:

1. In healthy people, when injecting water lower than body-temperature, horizontal and rotatory nystagmus are set up to the *opposite* side.

2. Water warmer than the body sets up rotatory nystagmus to the *same* side.

3. When the head is inverted (180°) the results are reversed.

When the vestibular apparatus is destroyed or its nerve paralysed no nystagmus follows syringing.

By this test unilateral destruction of function may be diagnosed.

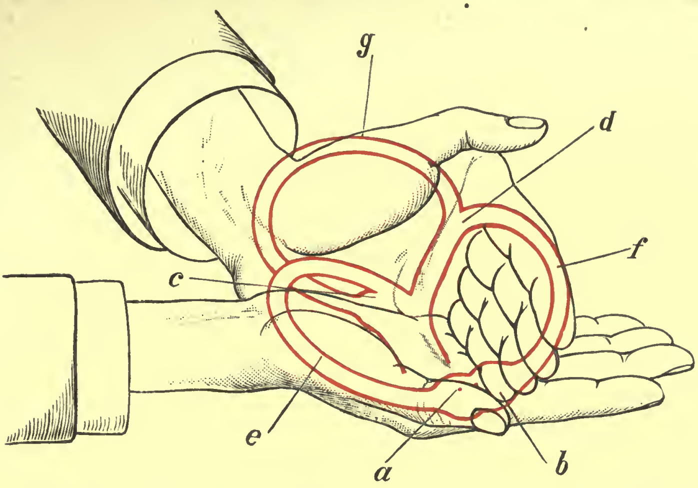

Fig. 231.—Mnemonic diagram of the canalicular system of the right ear. *g*, Posterior vertical canal; *c*, posterior vertical canal, its ampulla; *f*, anterior vertical canal (coronal): *b*, anterior vertical canal, its ampulla; *e*, horizontal canal; *a*, horizontal canal, its ampulla; *d*, confluence of the vertical canals. The ampullae of the horizontal and anterior vertical canals correspond with the right thumb and tip of left little finger respectively. The ampullae of the posterior vertical corresponds with middle of the metacarpal bone of left little finger. The confluence of the vertical canals corresponds with the heads of the left metacarpals.

It further has an advantage over the rotatory test that one side only is stimulated at a time, and that it is easier of application.

The direction of ocular movements in the *pressure* test varies, but in any single case the reaction of + pressure is always the reverse of that induced by − pressure. The pressure test evokes no reaction in health.

Dan. McKenzie has published an analysis of 42 cases examined according to Bárány's *caloric* test.[1]

He sought to obtain reliable data by measuring the time required to evoke nystagmus rather than the duration of the nystagmus itself.

For the cold test, water was used at 24° C.; for the warm, at 42° C.;

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[1] *Journal of Laryngology, Rhinology, and Otology*, vol. xxiv. Dec. 1909.

and was contained in a vessel kept at an elevation of 2 inches above the ear in order to maintain an even pressure.

It was found that in health nystagmus appeared in from 20 to 40 seconds; in increased sensibility of the vestibular organs, in from 5 to 15 seconds.

In cases of depressed excitability the induction period was from 50 to 120 seconds.

He came to the following conclusions:

In oto-sclerosis the activity of the vestibular sense bore no relationship to the severity of the deafness.

In noise and concussion deafness, and deafness following meningitis, vestibular reactions were impaired.

In hysterical deafness the vestibular sense was involved proportionately to the deafness.

In neurasthenia the vestibular system was hyperaesthetic.

In chronic uncomplicated suppuration of the middle ear vestibular reactions were normal.

In temporo-sphenoidal abscess the reactions were normal.

1. **Hyperaemia of Labyrinth.**—Simple hyperaemia of the labyrinth like anaemia is, doubtless, more frequently associated with general vascular variations rather than with alterations in the local blood-supply of the part. In cases, however, of acute middle-ear disease, especially when associated with the specific fevers, the labyrinthine vessels have been found by post-mortem examination to be markedly injected, as also in cases of meningitis, sinus thrombosis, and basal tumours. It may, therefore, be transient or persistent.

Aetiology.—One of the most striking causes, and one which has been closely observed, is in connection with caisson disease. Although the symptoms are generally more marked during decompression, especially when Eustachian patency is interfered with, they probably originate and are also felt when the pressure is positive. Either negative or positive pressure may be responsible by (1) causing violent variation of intra-labyrinthine tension by pressure through the fenestrae; (2) by inducing a general and local increase of blood-pressure; or (3) by sudden liberation of gas bubbles either in the blood-vessels or in the peri- or endo-lymph. Similar effects are also produced by any form of exposure to sudden changes in pressure, as during aerostation, mountain ascents, diving, gun-firing, motor-driving, etc. Hyperaemia may occur in the course of any of the specific fevers with or without meningitis, especially during the violent paroxysms of whooping-cough. All violent efforts which influence blood-pressure, arterial and venous, favour congestion of the labyrinthine and cerebral vessels, *e.g.* rage, coughing in patients suffering with bronchitis, pulmonary emphysema, asthma, cardiac disease, parturition, etc. To these may be added exposure to sudden changes in temperature, drugs such as quinine, amyl nitrite, nitro-glycerine, eucaine, and salicin. It has also been associated with alcoholism and the menopause.

It seems to be more common in early and late life. Congestion of the labyrinth occurs also in poisoning by carbon monoxide, lead, sulphuretted hydrogen, and chloroform. It has also occurred in patients suffering with a large goitre.

Finally, as already referred to, it may accompany acute and chronic disease of the middle ear, meningitis, both suppurative and serous, sinus phlebitis, and local endocranial neoplasms.

Pathology.—In the absence of definite evidence of the existence of direct vaso-constrictor and vaso-dilator nerve supply to the vessels of the labyrinth simple hyperaemia must in a great measure be interpreted as mechanical or chemical in origin. That the main source of blood to the labyrinth is controlled by a nervous mechanism is, however, highly probable, since the basilar artery is richly furnished with muscular fibres. In the present state of our knowledge it is unsafe to unduly emphasise vaso-motor influences in this region.

Another significant feature of the labyrinthine blood-supply is that its arteries have to pass through two sets of bony canals—first, on entering the skull, and, second, on their passage outwards through the temporal bone; so that, however responsive they may be to variations in the general blood-pressure, this is in a great measure balanced by rigid constriction in their course.

Hyperaemia occurs in two distinct forms: one in which the vessels—arteries, veins, and capillaries—are simply distended with blood, the other in which the vessels themselves exhibit structural changes such as atheroma, calcareous deposits, and pigmentation, with thickening of the membranous labyrinth itself. Leucocytic and lymphocytic blocking of the perivascular and other lymph spaces is a well-marked feature, especially when associated with meningitis and acute suppuration of the middle ear. In all instances of chronic thickening plasma cells are well marked, and afford striking evidence of the chronicity of the process. Distension of the venous radicles is, however, most marked when there is intracranial obstruction due to sinus phlebitis. Turbidity of the peri- and endo-lymph is due to the presence of leucocytes in acute, and amorphous, fatty and calcareous particles in chronic cases. A condition termed *hydraemia* has been noted chiefly in connection with arterial obstruction. It is characterised by general distension of the lymph spaces without cell infiltration, and is probably either a purely mechanical result or is due to post-mortem or dystrophic changes.

Kirchner has described marked hyperaemia of the labyrinthine vessels associated with middle-ear congestion due to quinine toxaemia.

In all instances, whether due to inflammatory changes or to vascular interference, there will obviously be some disturbance in the balance of pressure in the fluids. Hence any marked change in their quality, quantity, and pressure are likely to create well-marked symptoms.

Whether actual haemorrhage takes place in any of these cases is an open question.

Symptoms.—The clinical phenomena of labyrinthine congestion will vary in degree according to the nature of the cause or causes, but their type and character will be fairly constant. Giddiness, tinnitus, deafness, nausea, titubation, and ocular disturbances are the most prominent symptoms. They may be gradual or fairly sudden in onset, but are never so abrupt as in apoplexy of the labyrinth. The deafness, unless accompanied by middle-ear disease, is not very great, while nausea may not go so far as actual vomiting. There may be some slight nystagmus, but the ocular symptoms are chiefly subjective. Headache or a sense of fulness is always present.

As a rule the symptoms are transitory, and gradually disappear with the removal of the cause; but in the case of several soldiers seen by the writer who were exposed to the explosion of lyddite shells, complete relief was very gradual.

Diagnosis.—When unilateral and associated with middle-ear disease, acute or chronic, a diagnosis is not difficult; but when both ears are involved, or when accompanied by central and meningeal lesions, differentiation is less easy owing to confusion of signs. From true Menière's disease or apoplexy, the sudden onset, the intensity of the symptoms, and the maintenance of consciousness afford ample distinction. When associated with acute suppuration of the middle ear the symptoms of hyperaemia of the labyrinth do not disappear on inflation, and bone conduction is lost. Although tympanic congestion may be visible by otoscopy, too much reliance should not be placed upon such evidence as a means of differentiation from cerebral hyperaemia.

Treatment.—The treatment of labyrinthine hyperaemia will depend upon its cause. Complete rest in bed with the head elevated, combined with reduction of arterial pressure, are the most important objectives. Frequent doses of grey powder, alternated by hot saline purgatives, will rapidly reduce blood-pressure, especially when combined with hot applications to the abdomen and feet. Leiter's cold coil or ice caps to the head, with cupping or counter-irritants to the cervical spine, may be employed in the early stage. Bromide of ammonium and cardiac sedatives with non-stimulating diet are indicated. Quinine, alcohol, and tobacco should be avoided. Careful attention should be paid to the renal functions and to the avoidance of auto-toxaemia.

Persistently recurring attacks in plethoric and neurasthenic patients have been satisfactorily treated by setons.

2. **Anaemia of Labyrinth.**—Diminished blood-supply, or *anaemia* of the labyrinth, may be due to purely local conditions, such as aneurism of the basilar artery, obliteration of the internal auditory artery by growths, emboli, or atheromatous constriction; or it may be due to conditions influencing the general vascular system, such as any severe form of traumatic haemorrhage, parturition, chlorosis, pernicious anaemia, shock, poisoning by ergot or belladonna.

A purely local vaso-constriction due to direct sympathetic influences, referred to by several writers, is somewhat doubtful, and evidence afforded by morbid anatomy is confined to neoplastic and gross arterial changes.

The signs and symptoms of labyrinthine anaemia are not unlike those of haemorrhage into and irritation of the labyrinth, viz., tinnitus, deafness, nausea or vomiting, and giddiness, but as a rule they are less severe and not often attended with unconsciousness.

When due to splanchnic dilatation or cardiac weakness they are invariably ameliorated by lying down.

Treatment.—The treatment will be guided by the cause; merely transient attacks should be met with rest in the recumbent posture and diffusible stimulants, while general anaemia should be corrected by chalybeates, Levico water, and different preparations of iron, arsenic, and strychnia. Quinine is so uncertain in its action that it is better not to employ it at all. Cases associated with angio-neurotic phenomena are greatly relieved by inhalations of amyl nitrite.

Small doses of tincture of strophanthus will be found of great value in cases of functional cardiac weakness, as from excessive indulgence in tea and tobacco.

3. **Labyrinthine Haemorrhage.** — Labyrinthine haemorrhage, *i.e.* effusion of blood into the labyrinth, may be slight or extensive, and occurs under the following conditions: specific fever, especially mumps, diphtheria, smallpox, scarlet fever, and typhoid; renal diseases, glycosuria, leucocythaemia, pernicious anaemia, menopause, caisson work, cardiac disease, fracture of skull, explosions, concussions, as a complication of caries and necrosis of the temporal bone, meningitis (pyogenic and tuberculous), and in lunatics.

Such haemorrhages may be gradual or sudden in their onset, but to that form which appears with striking suddenness and without any premonitory signs or apparent cause, the term *Menière's Apoplexy* is especially reserved, and will be considered separately.

Haemorrhage into the labyrinth occurs occasionally in connection with parturition, whooping-cough paroxysms, and excessive straining during defaecation.

Further, it is generally associated with disease or damage to its bony walls, degeneration of its blood-vessels, and acute infection of the organ itself. In connection with disease of the antro-tympanic cavity there may or may not be actual erosion of its bony walls.

Extravasations vary considerably in nature and extent. They may be gradual in formation and due to small leakages, when the effusion will be more of the nature of a white clot, infiltrating or dissecting the fine strands of connective tissue, and undergoing organisation with patches of pigmentation; or they may be formed of red clot or unaltered blood situated in any part of the perilymph, most frequently, however, in the vestibule and first turn of the cochlea, either as small circumscribed patches or ecchymoses, or, as in traumatic cases, distributed through the whole organ, disturbing and compressing the canals. Intercellular and interfibrillary deposits of pigment, amorphous or crystalline, must not be confounded with the normal pigmentation associated with all peripheral sense organs. This is darker in colour, intracellular, and more frequently restricted to the cochlear and macular terminals.

In two cases of caries involving the labyrinth, the writer found extensive extravasation, old and recent, in the vestibule and cochlea, compressing, but not entering, the membranous canals. In one instance haemorrhage was traced from the vestibule into the internal auditory meatus along the internal auditory artery, and was associated with acute meningitis, complicating long-standing caries of the antrum. Invasion of the canals themselves by blood, with compression and destruction of the nerve elements, has been described by many observers (Moos, Steinbrügge, etc.). Such lesions must obviously be attended by severe or permanent loss of function, but post-mortem evidence often shows that although partial organisation and absorption of the effused blood may take place, considerable tracts of the cochlear and ampullary organs are permanently disorganised. Should the haemorrhage be slight and the leakage gradual, histological evidence shows that absorption of blood and recovery of function are not, in the absence of infection, impossible.

Note.—In the Toynbee collection are several specimens indicating old haemorrhages into the labyrinth.

4. **Menière's Disease.**—*Definition.*—By the term Menière's disease is meant a sudden apoplexy or haemorrhage into the labyrinth, occurring without any previous disease of the auditory apparatus, and presenting the familiar group of symptoms known as Menière's "complex" in varying degrees of intensity.

The disease itself is very rare, but the symptom-complex is not.

Aetiology.—As the material available for pathological research has been so limited, any expression of opinion on the actual cause must be given with reservation, and based more upon clinical observation than upon the study of anatomical details. The origin of the disease is rendered even more obscure from the fact that it attacks apparently robust and healthy adults in the prime of life, whose acoustic apparatus is apparently normal. It has been associated with the various forms of anaemia, leukaemia, renal disease, influenza, rheumatism, malaria, prolonged exposure to sunlight, and to great heat.

Pathology.—The subject of Menière's original observation died on the fifth day of the disease, but the necropsy as reported afforded no evidence of the cause of death. The semicircular canals, however, were filled with a haemorrhagic exudate which partly involved the vestibule but not the cochlea. Other observers have reported the presence of blood, exudate, fibrin, with sclerotic and other degenerations in all parts of the labyrinth. It must not, however, be overlooked that such extravasations have been demonstrated in patients who exhibited no Menière's symptoms whatever, and also that Menière's "complex" may be brought about by changes in the brain itself.

Menière's disease does not kill, and cases are seen in which some of the symptoms are so evanescent and so slight in degree that one is justified in assuming that the amount of blood extravasated was but little, and that the structural damage was but slight. It may be that the leakage is but scanty and readily absorbed, or is confined to certain regions of the labyrinth, judging from the great variations in the degree of each symptom. What the actual local changes are which are responsible for the haemorrhage, or which lead up to it, we can only surmise. That some degeneration in the labyrinthine vessels precedes the haemorrhage is more than likely, the actual attack probably coinciding with a sudden rise of general blood-presssure which these vessels are unable to adjust themselves to like those of the tympanum and elsewhere.

Symptoms.—The disease is not usually associated with any prodromata, as without any warning the patient may be seized with giddiness, tinnitus, deafness, nausea, and a slight degree of unconsciousness as if attacked by a fit. The face and skin may be pallid and bathed in sweat.

At first the symptoms may be only giddiness and tinnitus, for which the patient goes to bed. On awaking, however, and attempting to rise, he staggers, vomits, and falls to the ground, complaining of objects and of himself being in rapid rotation. After forty-eight hours' rest the vomiting and unconsciousness disappear, but giddiness, noises, and deafness persist. On inspection the tympanic membranes are found to be normal in appearance and the Eustachian tubes patent. Inflation only intensifies the deafness and tinnitus. Both air and bone conduction are diminished, or lost on one or both sides.

Nystagmus is well marked. The disease may be unilateral or bilateral.

Diagnosis.—It will be noted that the symptoms are confined to the labyrinth, a fact supported by careful examination of the ears. Other nerves are not affected, and the staggering is not attended by paralysis.

Reflexes are unaffected, and complete unconsciousness, as in cerebral haemorrhage, is absent.

Course.—The course of the disease will vary with the extent of the lesion. Sometimes there will be only one serious and sudden attack followed by progressive improvement, in others there may be one or several recurrences at shorter or longer intervals. As a rule, unconsciousness disappears in about twelve to twenty-four hours, vomiting persisting for perhaps a day longer, followed by occasional nausea for a week or two. Giddiness, however, persists, and although patients can walk with deliberation there is a certain amount of unsteadiness in the gait (titubation) possibly for months, especially in the dark or with the eyes closed.

According to Politzer and Guye, the handwriting is markedly affected, and improves with the restoration of equilibrium (this was probably in bilateral cases). With regard to the tinnitus, this, on the whole, will improve, but is liable to considerable variation, especially in those subject to kidney disease, goitre, and intestinal derangements. Auto-toxaemia of intestinal origin plays a prominent part in the production of tinnitus and vertigo. Except in very slight cases the hearing is permanently affected.

Treatment.—For the first forty-eight hours absolute rest of body and mind are indispensable. The room should be darkened, and the patient kept lying down with the head slightly raised. A free purge of calomel and a hot saline should be given to diminish blood-pressure, which may also be assisted by heat to the abdomen and feet. Cold may be applied to the head and venaesection had recourse to, but the application of leeches to the head is not likely to be of much service.

Later, bromides with mild saline aperients may be continued for a week or more, followed by a mild course of potassium iodide and arsenic and the inunction of mercury.

Tea, coffee, alcohol, tobacco, and quinine are to be carefully avoided, especially the latter. Pilocarpine may be commenced when all indications of possible recurrence have disappeared and the symptoms have been greatly ameliorated. It will greatly reduce the tinnitus, but has only slight, if any effect, upon the hearing.

Short and mild applications of the constant current may be used in the late period of the disease.

5. **The Labyrinth in Leukaemia.**—As in the retina, well-marked and characteristic lesions occur in the labyrinth during the progress of leukaemia (both splenic and medullary). The onset may be sudden or slow, but, as a rule, there is a sharply defined attack of Menière's symptoms with but slight deafness which rapidly increases, accompanied at first with well-marked nystagmus. In most of the recorded cases there was marked osseo-sclerotic thickening of the endosteum, but this was doubtless due to previously existing disease. The essential feature is haemorrhage with lymphocytic infiltration of both the endo- and perilymph canals, with consequent pressure and atrophy of the nerve terminals. In some cases the lymphocytic infiltration was concentrated in the endosteum, the canals being either free or containing blood-stained fluid. In severe cases the whole labyrinth was filled with blood and lymphocytes.

Differential examination of the exudate in one case showed a mixture of cells, there being large and small lymphocytes, mono- and polymorphonuclear leucocytes, and a few myelocytes. The red corpuscles were too much broken up to identify differentially.

Coincidentally with the labyrinthine changes there was considerable redness, oedema, and ecchymosis of the tympanic muco-periosteum, especially on its inner wall, which was also the seat of lymphocytic infiltration.

Note.—Excellent specimens of leukaemic labyrinthine haemorrhage were shown by Lake at the International Otological Congress, 1899.

6. **Syphilis of the Labyrinth.**—The rapid development of deafness, accompanied by incessant tinnitus and frequent attacks of vertigo, is very characteristic of syphilitic labyrinthitis. Occasionally deep-seated pain in the ear is complained of, and at times the periotic glands are found to be enlarged and tender. The disease is, as a rule,

bilateral, one ear being generally worse than the other. At times, however, it appears as a unilateral affection, assuming the type of an attack of Menière's disease.

Rapid and progressive loss of hearing takes place, as a rule, although there may be temporary pauses, followed by rapid exacerbations.

In cases uncomplicated by the presence of any tympanic lesion, bone conduction will be found to be much diminished, and Rinné's test to be positive. In unilateral cases the tuning-fork placed upon the vertex will be lateralised to the sound side. Tinnitus is present throughout the whole course of the disease, and frequently persists even after deafness has become complete, and after all vertiginous symptoms have disappeared.

Pathology.—Syphilis of the labyrinth shows itself either as a late secondary or early tertiary lesion. In the congenital form it may be present at birth, involving the middle ear at the same time.

In adults it usually begins in association with a special outbreak of tertiary symptoms, or may appear insidiously with or without antro-tympanic manifestations.

The lesions may be arbitrarily divided into three groups :—

1. Plastic or exudative.
2. Lymphocytic and sclerotic.
3. Granulomatous.

The first variety is rarely seen in adults, and is almost entirely confined to the congenital form in infants, and as a late secondary manifestation in adults with middle-ear catarrh.

The second group is marked by small cell infiltration of the endosteum, extending to the membranous labyrinth. Lymphocytes mingled with endothelial cells gradually replace the normal structures and undergo sclerosis, while the bone may be either osteo-porotic or sclerosed, changes which are histologically identical with or similar to those found in oto-sclerosis.

The granulomatous group is characterised by the formation of gummatous patches which spread by absorption of the bone, and give rise either to necrosis of considerable areas or to caries. Sequestra, which may consist of the whole or part of the bony labyrinth, are generally formed as the result of an acute superadded pyogenic infection. These granulations show considerable activity of their endothelial elements, which may even form giant-cell masses simulating tubercle, but without any tendency to caseation.

The presence of small blood-vessels, often the seat of *endarteritis obliterans*, further differentiates these growths from tubercle (Fig. 232).

Diagnosis.—The diagnosis of syphilitic labyrinthitis is easy, if at the time of the sudden onset of deafness other stigmata of syphilis are present, *e.g.* condylomata, mucous patches, skin eruptions, etc., supported by a + Wassermann's reaction. The existence of an underlying syphilitic dyscrasia should be suspected if sudden deafness appears in an adult unaccompanied by any evidences of middle-ear disease, and if there is a rapid and progressive loss of bone conduction, nocturnal headache, or persistent neuralgia. Pain is much more frequent than in tuberculous labyrinthitis.

In females and in elderly people an accurate diagnosis is frequently very difficult on account of the occasional and independent appearance of oto-sclerosis.

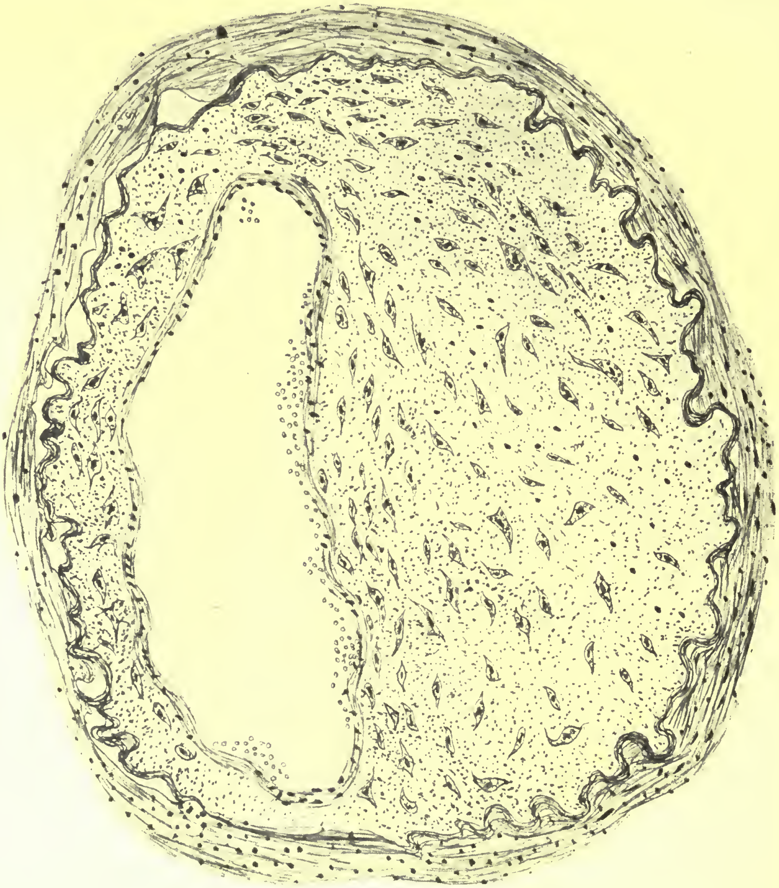

FIG. 232.—Endarteritis obliterans. Tertiary syphilis. Obj. $\frac{1}{8}$ in.

Congenital syphilitic disease of the labyrinth, unfortunately a most hopeless affection, is frequently associated with middle-ear changes, exudative, sclerotic, or purulent, with the presence of notched teeth (Hutchinson's), 50 per cent of the cases (Fraser[1]), and with interstitial keratitis and occasionally iritis, also with absent or diminished vestibular irritability. Its frequency is a matter of some doubt, certain authors considering that it is present in at least 10 per cent of all cases of congenital disease. It is unquestionably more frequently met with in females than in males, and commonly attacks the ears just as the interstitial keratitis is disappearing. According to Gradenigo, when the disease manifests itself about the time of puberty, it occurs twice as frequently in females as in males.

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[1] *Journal of Laryngol.*, Aug. 1909.

Prognosis.—The prognosis of labyrinthine syphilis is unquestionably unfavourable. In recent cases treatment, if energetically carried out, occasionally causes marked improvement, and even complete arrest of the disease. Relapses are, however, by no means uncommon. Youth, previous good health, a mild infection, healthy occupation, and good surroundings are favourable prognostic points; whereas old age, debility, a severe infection, and concomitant intra-tympanic or tubal lesions are distinctly unfavourable indications. In congenital cases the prognosis is, according to the experience of the writers, invariably unfavourable, while in those cases accompanied by marked corneal opacity it is almost hopeless.

Treatment.—Energetic antisyphilitic treatment should be at once instituted, accompanied by regular inunction and frequent hot baths. In cases where iodide of potash is not well borne, intra-muscular injections of mercury should be tried.

According to Politzer and other observers, great and lasting benefit arises from the subcutaneous injection of freshly prepared nitrate of pilocarpine, more especially when the deafness manifests itself about the commencement of the secondary stage of the disease. From 5 to 15 drops of a 2 per cent solution of nitrate of pilocarpine should be injected subcutaneously each day for a period of six weeks.

When, for various reasons, the drug cannot be administered subcutaneously, it may be taken in the form of tabloids *per oram.* The effects of "salvarsan" injections have not so far demonstrated any superiority over mercurial treatment.

When associated with middle-ear disease, inflation by means of the Eustachian catheter or the injection of a solution of iodide of potassium (gr. ii., oz. i.) into the middle ear affords at times slight relief. In very obstinate cases iodide or sulphur baths should be taken at some suitable Spa. In congenital cases the frequent and persistent application of blisters over the mastoid processes has been found to be of service.

Wassermann's Test for Syphilis, or Complement Fixation.—This is an adaptation of the Bordet Gengon method by Wassermann for the diagnosis of syphilis. The original technique is extremely complicated and delicate, demanding the attention of a skilled worker and the use of a fully equipped laboratory. It has, however, been so simplified that it is now available for general use as an aid to diagnosis. It is based upon the fact that there occurs in human blood a substance, *lysin*, which has the power of disintegrating the red corpuscles of some other animal, such as sheep. This property is fixed or neutralised by a substance in the blood of an immunised subject co-operating with an homologous substance or *antigen*, whereby haemolysis is prevented, and the reaction is said to be *positive.*

The simplified method is that used by Fleming,[1] the outcome of successive modifications by Levaditi, Landsteiner, Bauer, and Hecht, and when carefully and intelligently applied has proved quite reliable, although some observers prefer to employ the original and complicated technique of Wassermann.

The essentials are three :—

1. *An immune substance* (Syn. amboceptor or fixature) which is present in syphilitic serum.
2. *Complement* (Syn. cytase, alexine, lysin), present in all blood serum.
3. *Antigen.*—An alcoholic extract of a congenital syphilitic liver or a normal sheep's heart.
4. *Washed Sheep's Corpuscles.*—10 per cent in normal saline solution.

The antigen and washed corpuscles may be obtained in glass sterules, so that a careful observer, with but very simple appliances, may readily apply the test.

The method is as follows :—

Take five opsonic pipettes and introduce the following mixture.

1. Antigen, 4 vols. + syphilitic serum, 1 vol.
2. Antigen, 4 vols. + normal serum, 1 vol.
3. Normal saline solution + syphilitic serum, 1 vol.
4. Normal saline solution + normal serum, 1 vol.
5. Antigen, 4 vols.

Incubate at 37° C. for one hour, then to each add 1 vol. of 10 per cent washed sheep's corpuscles, and incubate for one hour.

The result in a syphilitic case would be that in Nos. 1 and 5 the corpuscles will be unchanged, while in 2 and 3 and 4 they will be disintegrated (haemolysis).

This reaction is positive Wassermann.

A supply of normal or isotonic (0·9 per cent) solution of sodium chloride will be necessary.

The patient's blood and the control should be taken from the thumb into a Wright's capsule or a narrow test tube, and allowed to settle or be revolved at arm's length.

The serum may then be drawn off by a pipette. The test should be applied *at once*, because the complement is very unstable.

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[1] *Brit. Med. Journ.*, October 2, 1909, p. 984.

CHAPTER XXXIV

OTO-SCLEROSIS VEL CAPSULITIS LABYRINTHI

Oto-Sclerosis (Syn. *capsulitis labyrinthi*).—*Definition.*—The term "oto-sclerosis" (von Tröltsch) is applied to a disease of the internal ear which is characterised by certain osseo-sclerotic changes invading the labyrinthine capsule, with progressive increase in deafness.

For many years it was included in the comprehensive term "dry catarrh of the middle ear." Although in 1861 Moos referred to an insidious form of inflammation attacking the stapedio-vestibular region, it is only recently that it has been accepted as a disease *sui generis.*

The pathological process is, however, unaccompanied by catarrhal symptoms, and must be very strictly differentiated from the various forms of adhesive catarrh of the middle ear so frequently met with. The clinical manifestations of the disease consist of a progressive loss of hearing, at times rapid, but more usually slow, unaccompanied by tubal obstruction or evidence of middle ear catarrh, although accompanied by constant high-pitched tinnitus, and by the presence of Paracusis Willisii.

Examination of the temporal bones of patients who have suffered from this affection shows fibrous or bony thickening in the region of the oval window, often to such an extent as to cause complete fixation of the stapes to the margins of its niche.

Microscopically, formation of newly formed fibrous tissue or bone will be seen to have taken place, the distinguishing feature in the latter case being the large size of the Haversian canals and canaliculi, and the presence of osteoblasts and osteoclasts around the young and newly formed blood-vessels of the part. Similar changes occur, although not so frequently, in the region of the round window, leading to its ultimate obliteration.

In uncomplicated cases of oto-sclerosis no changes, macroscopic or microscopic, are demonstrable in the tympanic mucosa.

Pathogenesis.—From time to time various views have been advanced as to the exact pathogenesis of this affection. According to Habermann[1] and Katz[2] its primary cause is a catarrhal inflammation of the tympanic mucosa. This view is also held by Scheibe[3] to apply to those cases in which definite changes are found in the middle ear.

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[1] *Arch. f. Ohrenhlk.* Bd. 60, 37.

[2] *Ibid.*

[3] *Verhandl. d. Deutsch. Otol. Gesellsch.*, Breslau, 1901.

Siebenmann[1] considers oto-sclerosis as an abnormal post-embryonal development originating in the cartilaginous cells lying between the primitive labyrinthine capsule and the bone which ultimately surrounds the true capsule.

The rarefaction which takes place, and which does not occur normally in the petrous bone, although it does in other bones, consists in the transformation of compact into spongy bone.

Politzer,[2] Moos, and Bezold look upon oto-sclerosis as being a pure osteitis affecting the pars petrosa, while other pathologists, *e.g.* Hanau, consider it to be an ossifying periostitis originally due to an infection of the tympanic mucosa. A. Gray,[3] on the other hand, considers that the essential factor in the disease is the death of circumscribed portions of the bone and cartilage, followed by absorption of the same portions and by the deposit of new spongy bone to take the place of the bone and cartilage which has been absorbed. This circumscribed death of bone may be induced by any circumstance unfavourably affecting the flow and the quality of the blood, *e.g.* anaemia.

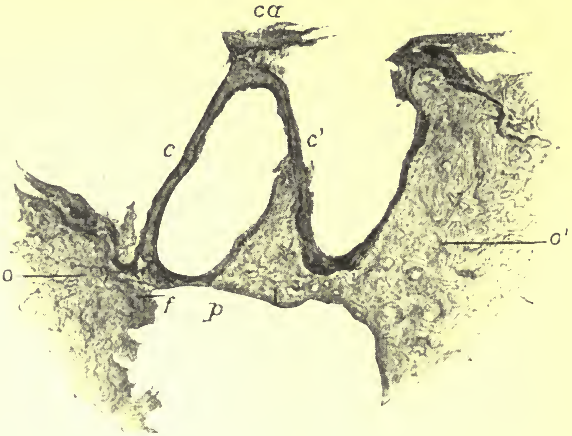

FIG. 233.—Synostosis of foot-plate of stapes and labyrinthine capsule. *ca*, Head of stapes; *cc'*, crura of stapes; *p*, base of stapes; *f*, synostosis of foot-plate of stapes and labyrinthine capsule; *oo'*, newly formed bone in labyrinthine capsule.

Exciting Causes.—Gout, rheumatism, syphilis, congenital and acquired, repeated chills, anaemia, chlorosis, the puerperium, and exhausting diseases causing profound nutritional changes have been held responsible for its incidence.

The syphilitic origin of the disease (Habermann) is not, however, borne out by clinical facts. In the first place the female sex is undoubtedly much more frequently affected than the male, the exact reverse occurring in syphilis; anti-syphilitic remedies have practically no effect; while suppuration, caries, and cario-necrosis, so frequently met with in syphilitic lesions, are conspicuous by their absence.

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[1] *Zeitschr. f. Ohrenhlk.* Bd. 34, 356, 291.

[2] *Ibid.* Bd. 25, 309.

[3] *Trans. Otolog. Soc.*, 1906, vol. vii.

Were it the outcome of congenital syphilis, pegged teeth (Hutchinson), interstitial keratitis, iritis, and cutaneous stigmata would be evident in many cases. Moreover, in a series of cases tested by Wassermann's reaction not a single positive result was obtained.

Morbid Anatomy—Pathology.—As already mentioned, the disease is essentially osseous in its character and distribution, involving the interior of the bony labyrinth, mainly the cochlear region. Whether the gross changes seen in a well-marked case are preceded by any definite inflammatory process has yet to be proved.

The lesion, as seen in advanced cases, is marked by the formation of highly cancellous, soft, or spongy bone derived from the endosteum of the labyrinth. This apparently also attacks the cartilage which covers the foot of the stapes on its vestibular aspect, and also that on the margin of the oval window with which it is in relation. Since the soft or ligamentous structures are involved the excursion of the stapes is soon limited, eventually ending in its complete fixation (Figs. 233 and 234).

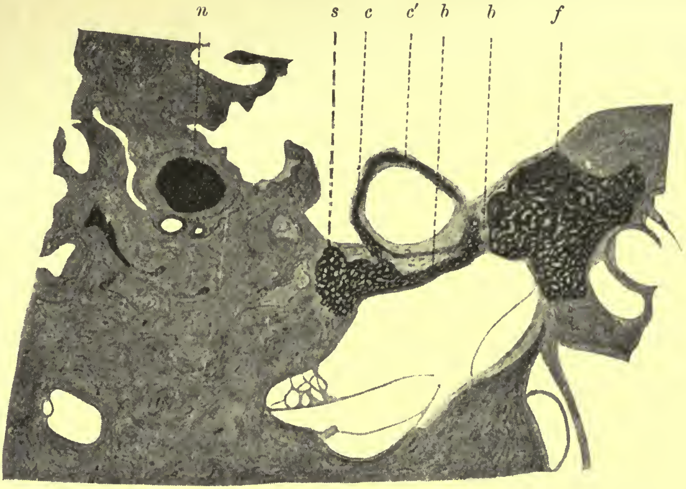

Fig. 234.—Synostosis of foot-plate of stapes and labyrinthine capsule. *cc′*, Crura of stapes; *b*, base of stapes; *f*, newly formed bone; *n*, facial nerve; *s*, synostosis.

There is some difference of opinion as to the exact sequence of events. One observer suggests that a zone or area of bone dies from some interference with its nourishment, that this is absorbed by osteoclasts, and replaced by osteoblastic formation of new cancellous bone in excess, and that this bone in turn becomes hard or petrous in type.

There can be very little doubt respecting the share taken by the endosteum in the formation of new bone, a process which occurs normally, but in this instance the process is so excessive as to constitute a morbid process, since it sooner or later involves the membranous labyrinth itself together with nerve terminals, fibres, and ganglia.

Whether the primary lesion is to be found in a sudden or gradual obliteration of the vascular supply to the diseased region by thrombosis, arterio-sclerosis, or from general nutritive changes, is still undecided.

That the disease is often strikingly limited to the labyrinth, leaving the tympanic cavity unaffected, has been amply proved by many observers. This is a most significant point since the labyrinth has its own special vascular supply, viz. the internal auditory artery, a branch of the basilar. Although the labyrinth receives in addition a few minute vessels from the stylo-mastoid artery, and from others supplying the middle ear according to Quain, no anastomosis takes place between them.

To more fully understand the significance of the histological changes reference should be made to the chapter on the normal anatomy of the internal ear (p. 433). The structure and connection of the bone and capsule, and of the endosteum and membranous labyrinth are so intimate that vascular disturbance of the one necessarily involves all.

The formation of cancellous and its replacement by compact bone is, after all, a normal process in kind, but abnormal with respect to life, period, and degree.

While oto-sclerosis may involve the whole or portions only of the labyrinth, it is not surprising that the stapedio-vestibular region, from its greater functional activity, should be the most frequent and often the primary site of disease, the upper and anterior margins of the *fenestra ovalis* being the "seat of election" for the deposit of new bone.

Attention may here be drawn to the fact that no observation has been recorded of any involvement of the semicircular canals in spite of the extensive damage done to the vestibule in the neighbourhood of the fenestrae. The chief extension of the lesion seems to be towards the cochlear tube and not towards the semicircular canals. There is certainly but slender evidence of the canals being involved either histologically or clinically. Disturbance of equilibration and nystagmus are never prominent symptoms. The lesion therefore appears to select the acoustic rather than the equilibrating segment of the internal ear. This feature somewhat supports the views of those who refer the primary origin of the disease to the tympanum. It may be, however, that the semicircular canals are actually involved, but that the process is so slow and gradual as to be effected without any corresponding or coincidental phenomena.

Aetiology.—Oto-sclerosis is met with more frequently in females than in males, and is more common between the ages of fifteen and thirty.[1] In the case of two sisters, aged respectively twelve and fourteen, coming under the author's observation, advanced oto-sclerosis was found.

Bezold, in an analysis of cases of *capsulitis labyrinthi*, found 61·2 per cent in females; Denker 58·2 per cent in females, and 41·87 in males;

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[1] Denker (*Die Otosklerose*, 1908), in an examination of 306 cases, found that the disease began between the ages of twenty and fifty in 77·7 per cent, 26 of the cases were affected in the second decade, and 11·1 per cent after the fiftieth year.

N. H. Pierce 60 per cent in females; while the author, in an analysis of 100 cases occurring in private practice, found 57·5 per cent in females, and 42·5 per cent in males.

The hereditary nature of oto-sclerosis is now fully established, several members of the same family being frequently affected, transmission showing a marked tendency to run through the female line.

In an examination of 306 cases Denker found a history of heredity in 40·5 per cent, Bezold in 52 per cent, and Siebenmann in 30 per cent. In five families examined by Körner[1] 43 cases of oto-sclerosis occurred, seventeen of the patients being males.

Inherited and acquired syphilis, rheumatism, gout, uricacidaemia, anaemia, and rickets are frequent associated if not causative factors.

It is also by no means uncommon to find osteoporosis develop during the puerperium, and to become markedly worse after each confinement, anaemia, chlorosis, and nutritional anomalies being apparently predisposing causes.

Young women, the subjects of atrophic rhinitis (*ozaena*), are peculiarly prone to this form of progressive deafness. Severe and prolonged mental strain is also said to act as an exciting cause of the disease.

Oto-sclerosis may be, and is occasionally, associated with various forms of middle-ear disease, *e.g.* adhesive catarrh, and at times with diffuse hyperostosis of the external auditory meatus. It is usually a bi-lateral affection, although generally considerably more advanced in one ear than in the other.

Symptoms.—Progressive loss of hearing is invariable, and depends upon a gradually increasing obstruction to the passage of sound-waves through the labyrinth, and ultimately upon organic changes within the labyrinth itself. Various factors tend to increase the existing degree of deafness, as, for example, intercurrent attacks of anaemia, child-bearing, catarrhal affections of the upper respiratory tract, over-fatigue, mental worry, or general exhaustion. Atmospheric conditions, which play such a prominent part in catarrhal conditions of the middle ear, have a comparatively slight effect in cases of true oto-sclerosis. The loss of hearing, which at first is slight, gradually increases until the patient is practically cut off from social intercourse, and falls into a low, nervous, and depressed state of mind. Pain is, as a rule, absent unless some intercurrent attack of middle-ear inflammation takes place, although it is occasionally complained of in the depths of the ear or about the mastoid process. Symptoms of heaviness in the head and general mental hebetude are common, but vertigo, giddiness, or any disturbance of equilibrium are entirely absent, which is somewhat remarkable in view of its pathology. The most distressing symptom, apart from loss of hearing, is constant tinnitus, which occurs in from 70 to 80 per cent of cases. In no form of ear disease are subjective noises so persistent and so usual. In nervous, hysterical, and anaemic women these subjective noises are peculiarly troublesome, and increase as the deafness progresses. Even in cases when for all practical purposes deafness is complete, persistent tinnitus may remain. In other cases, however, total loss of hearing is accompanied by a subsidence of all subjective sounds. Tinnitus may precede the onset of deafness by many months or even years. When persistent, and appearing in a case unaccompanied by signs of catarrhal middle ear disease or labyrinthine involvement, it should arouse a suspicion of commencing oto-sclerosis. Paracusis Willisii, or hearing better in a noise (see p. 54), is invariably present, except in those cases where extensive involvement of the cochlear canal has taken place. The loss of hearing for speech proceeds, as a rule, *pari passu* with a loss of hearing for both watch and acoumeter. Whispered speech is at times heard more readily, and at a longer distance than ordinary conversation. In rare cases the power of hearing a watch and musical notes of high pitch may remain even when marked deafness for speech exists. The perception of sound through the cranial bones, *e.g.* by tuning-fork or watch, is preserved so long as the auditory nerve and its terminals remain intact. In unilateral cases Weber's test is positive, Rinné's negative. When both ears are affected, if the power of hearing upon one side is much greater than upon the other, Weber's test is positive upon the deafer side. As the disease advances, Rinné's test, which at first is negative, becomes positive. The highest notes of a Galton's whistle or Edelmann's "pfeife" are heard, even when the auditory nerve is undoubtedly implicated. It may happen that certain portions of the nerve are affected, other portions remaining healthy. In such cases "islands of hearing" remain, especially for musical sounds and sounds of high pitch. Vertigo occurs in a very small percentage of cases.

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[1] *Zeitschr. f. Ohrenheilk.*, 1905, vol. 50.

Diagnosis.—In a case of typical oto-sclerosis the membrana tympani appears normal, with the exception that in its posterior segment a flamingo-like appearance is found, due to the existence of dilated tympanic blood-vessels upon the pars promontoria in the region of the pelvis ovalis. This appearance is, however, not met with in pure nerve deafness (Siebenmann).

Catheterisation of the Eustachian tube shows the absence of all obstruction, the air entering the tympanic cavity freely and producing the ordinary auscultatory sounds. If under such circumstances progressive deafness is associated with constant tinnitus, Paracusis Willisii, an absence of vertigo, prolonged bone conduction, a negative Rinné, and preservation of the upper tone limit, the existence of oto-sclerosis may be considered certain. In mixed cases where an adhesive process co-exists with oto-sclerosis, a final diagnosis is only arrived at after the lapse of considerable time. In such cases also marked objective changes may have taken place in the membrana tympani, such as opacity, patches of atrophy, calcareous degeneration, retraction, or adhesion combined with tubal obstruction and evidences of naso-pharyngeal catarrh. These various catarrhal or adhesive changes produce progressive deafness, constant tinnitus, and practically the same tuning-fork tests as are found in oto-sclerosis. The diagnosis of a mixed condition is, therefore, only possible after careful and prolonged observation, and as a result of the effects of treatment.

The exact location of the pathological process modifies to some extent the various functional tests. Thus when osteo-porosis is most marked around the oval window bone conduction is found to be materially lengthened and Rinné's test markedly negative. On the other hand, when the vestibular capsule and the cochlear canal are mainly affected a negative Rinné is decreased, if it does not actually become positive, and Schwabach's test is shortened.

The following functional symptoms (Bezold's triad) indicate the existence of oto-sclerosis :—

1. Increase of bone conduction.
2. A well marked negative Rinné.
3. An elevation of the lower tone limit.

Gellé's test, the actual value of which in cases of oto-sclerosis has been much disputed, furnishes, if carefully applied, evidence which, according to the writer's experience, is of distinct value, especially as a control to the results obtained from the Rinné reaction.

The deductions made by Gellé are :—

1. A positive Rinné and a positive Gellé are evidence of nerve deafness.

2. A negative Rinné and a negative Gellé exclude nerve deafness.

3. The combination of a positive Rinné and a negative Gellé indicate fixation of the stapes and internal ear deafness.

Prognosis.—The more rapid the progress of the disease the more hopeless is the prognosis. Hereditary tendency to this form of deafness, so very frequent, severe degrees of anaemia, inherited syphilis, and early impairment of the auditory nerve as evidenced by loss of perception for high tones and diminished bone conduction, are also factors of ill omen.

Treatment.—Unfortunately, up to the present time all efforts to cure this form of progressive deafness have proved unavailing. Its alleviation, even for a time, is a matter of the utmost difficulty and uncertainty, and in general it must be confessed that the methods of treatment now in use are entirely unsuccessful. Its hereditary nature and the pathological changes demonstrated by microscopic examination render it unlikely that any satisfactory method of treatment is possible. In the opinion of the authors, much harm is often done by excessive zeal in treatment, such as the too frequent use of inflation, massage, intranasal surgical procedures, removal of septal spurs, cauterisation of the turbinated bodies, and removal of small tufts of adenoid tissue, which, although present, have no relation to the incidence of oto-sclerosis. Such treatment serves only to arouse a feeling of hopefulness, followed later, unfortunately, by more pronounced despondency. A word of comfort may be given to the patient by the statement that the progress of the disease is essentially slow and that it may become spontaneously arrested. The exceptional cases in which a rapid and sudden loss of hearing takes place are so few in number that for the time being they may be disregarded.

The continuous employment of phosphorus has been strongly advocated upon the grounds that it has the power of arresting osteoporosis. It may be administered in pill form or in solution (Kassowitzsch's emulsion $\frac{1}{10}$ per cent).

Siebenmann, who has made an extensive trial of this drug, claims that in 50 per cent of the cases good results are obtained. On the other hand, Sugár[1] considers that the administration of phosphorus for prolonged periods is not without danger. The writers, who have made a prolonged trial of the drug, have been forced to the conclusion that its administration, beyond improving to some extent the general health, is of no particular value.

Intratympanic injections of vapours and fluids have been tried, *e.g.* warm air, steam, chloride of ammonium, fluid vaseline, iodide of potassium, pilocarpine, fibrolysin and pepsine. The results in almost all cases have been *nil*, while in some the treatment has been followed by distinct deterioration of hearing power.

Fischerich[2] claims that the intratympanic injection of pilocarpine is useful, an experience which the writers are unable to corroborate as the result of the careful observation, extending over a period of two years, of a series of 24 cases of typical oto-sclerosis.

The question whether patients suffering from this disease should be cautioned against marriage opens up many points of interest and difficulty. That the disease has a markedly hereditary tendency is undoubted, and that in almost all cases it becomes worse during the puerperium and remains worse after confinement, is also an every-day experience. Whether under such circumstances marriage is advisable is very doubtful. In the opinion of the authors, it is the duty of the medical attendant to draw the patient's attention to these facts.[3] If both the prospective bride and bridegroom suffer from oto-sclerosis marriage is most inadvisable. In a case recorded by Körner where both parents suffered from oto-sclerosis, each one of the twelve children born of the marriage developed typical oto-sclerosis with all its attendant disqualifications.

When oto-sclerosis occurs in a patient the subject of inherited or acquired syphilis, gout, or rheumatism, suitable medical treatment should be at once instituted. Iodide of potassium or sodium is recommended by Politzer and Voltolini in early cases. Doses of 10 to 15 grains in half a pint of water should be given daily for a few weeks and repeated three or four times a year. Vulpius[4] recommends the internal administration of thyroid extract. An extensive trial of this drug in the author's clinic has only served to show its utter uselessness. The long-continued administration of subchloride of mercury in doses of

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[1] *Archiv f. Ohrenheilk.* Bd. 76, 36.

[2] *Laryngoscope*, Jan. 1900.

[3] *Trans. Otolog. Soc.*, 1906, vol. vii.

[4] *Archiv f. Ohrenheilk.*, July 1896.

$\frac{1}{10}$th of a grain three times daily or of chalk and mercury pills (gr. $\frac{1}{5}$ ter in die) is said to relieve symptoms, especially tinnitus.

Pneumo-massage, either by means of a hand, water, or electrically driven motor has been much employed and with somewhat varying results.

Politzer[1] regards it as of value if employed in the early stages of oto-sclerosis, and as of no value whatever in advanced cases when anchylosis of the stapes is complete.

Zaalberg[2] found a moderate improvement in hearing in some of his cases and a marked lessening of subjective noises.

Schwabach[3] considers it to be of little value.

Yearsley,[4] in 15 cases (30 ears) found but 1 case in which any benefit was derived. He believes that in conjunction with other methods of treatment it may possibly prove of value in early cases.

In a series of private cases coming under the author's observation the results proved most disappointing, not one single patient benefiting so far as audition was concerned, and only a small percentage deriving any relief, and that very temporary, from the incessant tinnitus. In fact it appeared in some instances as if it accelerated the loss of hearing and increased the tinnitus.

If pneumo-massage be employed an electro-motor masseur (Lake) should be used, with a velocity of from 3000 to 4000 vibrations per second and with a stroke not exceeding 2 mm. Treatment should begin with half minute sittings gradually extended to one or even two minutes daily.

When oto-sclerosis is complicated with catarrhal middle-ear disease or tubal obstruction, treatment is to be directed to the latter. The various methods of treatment already detailed for such cases (p. 179) should be tried, and any definite form of nasal obstruction attended to. Should inflation by means of Politzer's bag or the Eustachian catheter produce an improvement in the range of hearing power, and should the improvement last for a few days, energetic treatment of the co-existing catarrhal processes, either nasal or aural, should be undertaken. Not infrequently it increases the symptoms, especially when there is any nerve deafness.

A purin-free and vegetarian diet, combined with the administration of a good red wine—burgundy or claret—is beneficial. Turkish baths, general massage, and graduated exercises are of value from the point of view of promoting increased nutrition and general well-being.

From time to time various operative measures have been advocated. In cases where tuning-fork tests show an absence of impairment of the auditory nerve, Kessel recommends *mobilisation of the stapes*. This operation has been extensively employed by Boucheron and Miot in France, and by Jack in America.

After careful disinfection of the meatus a crescentic incision is made along the postero-superior margin of the membrana tympani. The flap thus formed is drawn forwards, exposing the inner tympanic wall. A solution of equal parts of cocaine hydrochloride (10 per cent) and adrenalin chloride (1 to 1000) is then applied until the mucosa is dry and blanched. By means of a small spatula-shaped probe or delicate hook introduced through the artificial perforation in the membrane, the incudo-stapedial articulation is gently massaged. Unfortunately, even although mobilisation practised in this manner produces temporary improvement, contraction of tissue again takes place, with the return of a great, if not a greater degree of deafness than before. In advanced cases, when bony proliferation around the foot-plate of the stapes exists, this method is obviously useless.

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[1] *Diseases of the Ear*, 1902.

[2] *Monatschr. f. Ohrenhlk.*, 1900, No. 8, p. 309.

[3] *Archives of Otolog.* vol. xxx. p. 283.

[4] *Journal of Laryngol.* Oct. 1907.

The immediate effect of mobilisation of the stapes is to produce an increase of subjective noises and dizziness, and occasionally also of headache. Suppuration rarely results, but injury to the chorda tympani nerve with loss of taste upon the same side of the tongue, and dislocation of the incudo-stapedial articulation, are not unlikely.

Extraction of the Stapes.—Extraction of the stapes has been recommended by Kessel, Grunert, and Faraci. So long as the foot-plate is not anchylosed to the margins of the fenestra ovalis no particular difficulty is encountered, although it is impossible to completely remove its cartilaginous rim and to avoid injury to the vestibule. In advanced cases the removal of the foot-plate is impossible on account of bony adhesions.

The method of operating is as follows:—A window is made in the postero-superior segment of the membrane by means of a knife or cautery point, and the stapedio-vestibular articulation brought into view. The tendon of the stapedius muscle is severed and the incudo-stapedial articulation divided by a specially constructed knife. The stapes, grasped by a hook or pair of forceps, is pulled from its attachment to the margins of the fenestra ovalis. The patient should be confined to bed for a few days, and kept lying flat, with the affected ear uppermost, on account of the vertigo and sickness induced as a result of the operation, and to prevent, so far as is possible, escape of cerebro-spinal fluid. Temporary improvement frequently takes place, but the experience of most operators is against the procedure, and a consideration of the histopathology of oto-sclerosis should show the utter futility of any such operative procedures where it is impossible to prevent the progressive bony occlusion of the fenestra ovalis and thickening of the labyrinthine capsule.

Somewhat more favourable results have followed division of fibroid adhesions uniting the foot-plate of the stapes to the margins of the fenestra ovalis (synechotomy). Unfortunately, cicatricial contraction and re-formation of adhesions almost inevitably results, so that the operation, although providing temporary improvement, has no lasting beneficial effect.

Removal of the entire membrana tympani, the malleus and incus, formerly strongly advocated by Sexton of New York, has now been given up.

So far no operative measure has proved of the slightest permanent value, and considering the hereditary nature of the affection and the peculiar pathological changes which take place, it is unlikely that surgical interference will ever relieve this distressing and progressive form of deafness.

CHAPTER XXXV

INFLAMMATION OF THE LABYRINTH—NON-SUPPURATIVE AND SUPPURATIVE

Inflammation of the Labyrinth (*Otitis interna*).—Although not infrequently occurring as a secondary complication of middle-ear disease in adults, in its primary form it must be considered as essentially a disease of childhood. Both in meningeal and in middle-ear disease there must always be some doubt as to the exact extent to which the labyrinth is actually involved, or in how great a measure it is responsible for certain symptoms, since many of the immediate and after phenomena may be explained by involvement of the auditory nerve in its intracranial course. Extended clinical and pathological observations, however, clearly show that the labyrinth is more frequently involved than was once supposed to be the case.

Primary inflammation of the labyrinth, although probably a rare affection, has been fully established by Politzer, who relates the case of a child attacked by sudden and permanent deafness during a febrile disease, in whom necropsy several years later revealed complete destruction of the labyrinthine contents with a normal tympanic cavity. The undegenerated auditory nerve could be traced into the newly formed tissue. Inflammation *secondary* to or coincidental with suppuration of the middle ear is by no means rare, either in the acute or chronic form. In the latter case it generally coincides with an acute exacerbation set up by a superadded infection, *e.g.* influenza, erysipelas, or tubercle. It is often found in acute suppuration of the middle ear due to scarlet fever, measles, typhoid, or smallpox, and may be part of the general infection, or due to local extension. The latter variety is more common in childhood while the former may occur at any age.

Labyrinthine inflammation may occur in association with meningitis —septic or epidemic—either during the attack or as a sequel, in which case both ears are generally involved. Infection may be carried by the ductus endolymphaticus, the perineural sheath of the auditory nerve, or the perivascular lymph spaces surrounding the internal auditory artery.

The local changes will vary in degree and extent according to the intensity and nature of the infection. These may be simply alterations in the quantity, quality, and pressure of the labyrinthine fluids or profound cytological disturbances. It is probable that many of the symptoms may arise from purely toxic influences upon the nerve terminals, unattended by any structural changes. Usually, however, there is actual invasion of the cavity by pyogenic bacteria, resulting in suppuration. This may terminate in resolution with but slight and transitory improvement of function, but as a rule, owing, probably, to the rigid and unyielding walls, permanent damage is done to the delicate acoustic and vestibular organs, either from pressure or from the tryptic action of the pus products.

As a result of a severe suppurative and extensive process, necrosis and exfoliation of the whole or a portion of the bony labyrinth may take place, or the more gradual process of caries, with the formation of granulation tissue. Both varieties are seen in connection with tubercle and syphilis. Following suppuration of the milder degree are calcareous, caseous, and pigmentary changes, with more or less atrophy of the membranous labyrinth. The Toynbee collection has many specimens illustrating variations in the fluids, also pigmentation, calcific deposit, atrophy of the labyrinth, and sclerotic changes, which, although occurring more frequently in old patients, indicate, from their histories, an inflammatory rather than a senile origin.

Published records of labyrinthine infection include but few varieties of bacteria. In the writer's experience a small Gram – diplococcus which grows with difficulty on agar or serum, but readily on nasgar, is frequently found. It conforms to the character of Weichselbaum's meningococcus, and is probably identical with it. The pneumococcus (Gram +) of Fraenkel is of frequent occurrence, as also the larger Gram – *diplococcus catarrhalis*, the *bacillus pyocyaneus*, *bacillus proteus vulgaris*, and the *streptococcus pyogenes*.

A review of the specimens in the writer's possession shows that the cochlea and the vestibule are more frequently the seat of granulation tissue changes than are the semicircular canals. Such granulations probably afford an effective barrier against intracranial infection by way of the internal auditory meatus.

A condition in which the labyrinth and middle ear are simultaneously attacked in the course of scarlatina and diphtheria is termed *panotitis*. The pathological changes are of a severe septic or plastic type, and are associated with serious local and constitutional symptoms.

Prognosis.—All varieties and degrees of acute inflammation of the labyrinth are unfavourable in their outlook, according to the intensity of the attack, the extent of the area involved, and the promptness of or delay in their recognition. Unfortunately, the cochlear organ is so often involved, that unless the inflammation is slight in degree, recovery of hearing power is unlikely, or at all events, is but partial.

Exfoliation of the whole or part of the bony labyrinth is a result more frequently associated with syphilis, but also sometimes occurs in tuberculosis. In either case a superadded, acute, septic infection is the immediate cause of the necrosis. Doubtless the special blood-supply of the structure and the limited anastomosis between its vessels and those of the antro-tympanic cavity are predisposing causes, since a sudden arrest of the blood-supply is thus specially favoured. Further, the scanty supply of blood-vessels in tuberculomatous tissue, and the obliterating processes so characteristic of syphilis, are probably also factors of importance.

The Surgical Treatment of Non-Suppurative Affections of the Labyrinth.—Operative procedures upon the labyrinth have up to the present been mainly confined to the relief of purulent disease the result of infection spreading from the cavity of the middle ear (p. 480), and the indications for operation are now well understood, the results obtained having in the main been eminently satisfactory.

In cases of non-suppurative labyrinthitis, when loss of hearing is marked, when tinnitus and vertigo are so distressing as to make the patient's life a burden, and when prolonged medicinal treatment has entirely failed to afford relief, the advisability of complete ablation of the internal ear or division of the auditory nerve as it enters the internal auditory meatus has to be considered. Unfortunately, it is not as yet possible in any given case to state whether tinnitus is due entirely to peripheral or central changes, hence a positive diagnosis of the exact site of the lesion is not always possible. Another objection to surgical interference with the internal ear in non-suppurative cases is that the operation is by no means free from danger, that a direct communication is made with the cerebro-spinal fluid, and that as a consequence there is a definite risk of septic basal meningitis supervening. Notwithstanding the objections above stated, there are cases in which the risk must be accepted by both patient and operator, cases where the patient, owing to his severe vertiginous symptoms is unable to follow his occupation, or when from persistent tinnitus such an amount of mental depression is induced as to lead at times to the thought of suicide.

Division of the Auditory Nerve in the Posterior Fossa.—This operation was first performed by Wallace and Marriage[1] upon a female aged twenty-three, who suffered from intolerable tinnitus and vertigo. The lateral sinus was divided between two ligatures and the cerebellum drawn to the side. The auditory nerve was reached after considerable difficulty and divided. Death, however, took place twenty-one days later. In 1907 Parry[2] divided the auditory nerve in a male patient aged thirty. The operation consisted in the formation of a large osseo-cutaneous flap through which the nerve was approached from above the tentorium. Milligan has on two occasions divided the auditory nerve, in one case by approaching it from behind the lateral sinus, in the other from above the tentorium. In the former case, a female patient, death resulted from shock, the outcome apparently of the loss of an enormous amount of cerebro-spinal fluid; in the latter the result was quite satisfactory, the patient, a male, losing the vertiginous symptoms of which he chiefly complained, and being able to resume his occupation, that of a bricklayer. D. Armour, C. A. Ballance,[1] and Krause have also recorded cases.

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[1] *Lancet*, 1907, i. 1192.

[2] *Trans. Otolog. Soc.* v. 62.

The published records, with results tabulated by R. Lake,[2] are as follows:—

Operator.	No. of Cases.	Result.
Krause . . .	1	Death.
Parry . . .	1	Failure.
Wallace . . .	1	Death.
Armour . . .	1	Successful.
Milligan . . .	2	Successful. Death.
Lannois . . .	1	Failure.
Ballance . . .	1	Failure.

Deaths, 3; failures, 3; successes, 2.

These results are by no means very encouraging; and considering the great severity of the operation, the production of profound shock, and the great possibility of injury to the facial nerve, it is very questionable whether it should ever be undertaken. Milligan has, after an experience of two cases, definitely abandoned it in favour of the operation of total extirpation of the cochlea.

Extirpation of the Cochlea (Lake).—This operation has been successfully performed by R. Lake, Murison and Yearsley, and Milligan. In order to obtain sufficient room the musculo-cutaneous flap suggested by Lake should be fashioned. A long and slender knife is introduced into the meatus with its edge so directed as to lie between the tragus and commencement of the helix. An incision is then made between the junction of the anterior and superior walls of the meatus, and carried upwards until the upper insertion of the concha is reached. It is then swept backwards and downwards to about the middle of the posterior attachment of the auricle (Fig. 235). The auricle and auditory meatus are then lifted from their superior attachments, wrapped in sterile gauze, and turned downwards and out of the way. The complete radical mastoid operation is then performed, bone being freely cut away so as to permit of an uninterrupted view of the inner wall of the middle ear. The *pars promontoria* is then removed with a narrow and highly-tempered gouge. The modiolus, which is then brought into view, is cut away with a narrow chisel, and the cavity thus formed gently curetted. The flow of cerebrospinal fluid which takes place, and which is protective, is readily arrested by tamponing with sterilised wax.

The whole operation area is then carefully disinfected and packed with gauze, the auricle replaced, and stitches inserted.

Total ablation of the cochlea has been performed by R. Lake in 5 cases with the following results: cure, 1; great relief, 1; no improvement, 2; no tinnitus, but quite deaf before operation, 1; and by Milligan in 6 cases, with 4 successes, 1 death from basal meningitis, and 1 complete failure.

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[1] *Lancet*, Oct. 10, 1908.

[2] *B.M.J.*, Oct. 16, 1909.

In 1885 Orne Green removed the stapes and passed a fine probe into the vestibule in order to break up the membranous labyrinth, while Botey recommended opening the cochlea through the round window.

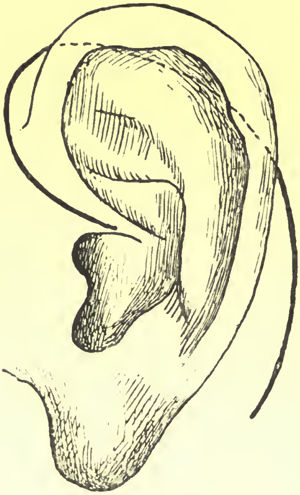

FIG. 235.—Lake's incision (as used in operations for extirpation of the cochlea).

The outer wall of the cochlea has also been opened per meatum—in the writer's opinion an unsurgical procedure — with, however, a successful result.

Partial or total ablation of the semicircular canals, with or without removal of the outer wall of the vestibule and a portion of the cochlea, has been performed by Lake[1] and by Milligan[2] with success in patients suffering from severe vertiginous symptoms with or without tinnitus.

Panotitis.—In this disease the middle and internal ears of both sides are affected either simultaneously or the one very shortly after the other. It is more common in children than in adults, especially as the result of scarlatinal diphtheria, runs a rapid course, and leads to profound deafness.

Symptoms.—It is ushered in by a sudden rise of temperature, deep-seated boring pain in the head, and frequently by convulsions and ultimate loss of consciousness. When the patient recovers consciousness he is frequently found to be quite deaf, and to have a discharge from both ears. There is also pronounced vertigo and a staggering gait.

Prognosis.—The prognosis is extremely bad, little or no hearing power ever returning. It is not, however, quite so unfavourable in cases of diphtheritic origin.

Treatment.—The repeated application of blisters behind the ears and the internal administration of iodide of potassium or ammonia in small doses is advised, but in the writer's experience has seldom proved of any value. The subcutaneous injection of 4 or 5 drops of muriate of pilocarpine daily, for a period of from four to six weeks, has occasionally proved of value, especially in cases of purely diphtheritic origin.

Suppuration of the Labyrinth.—Although pyogenic infection of the labyrinth is, in the vast majority of cases, the outcome of previous suppurative disease of the middle ear and its adnexa the authors consider it advisable on practical grounds to discuss its symptomatology and treatment at this point.

According to the writer's observations pyolabyrinthitis, exclusive of cases of localised erosion of the outer labyrinthine wall, is present as a complication in from 1 to 2 per cent of all cases of suppurative middle-ear disease, acute and chronic. It is, therefore, a more frequent complication of middle-ear sepsis than even intracranial lesions (meningitis, brain abscess, or sinus thrombosis) combined.

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[1] *Trans. Otolog. Soc.* v. 69.

[2] *Journ. of Laryng.*, Aug. 1907.

It is more frequently met with in males than in females, and is generally unilateral.

It may be *manifest* or *latent*, the latter variety lighting up at times with symptoms of great urgency.

It is due to one or other of the following causes :—

1. Extension of pyogenic infection from the antro-tympanic cavity.
2. Pyogenic infection originating about the base of the brain and extending along the peri-vascular and peri-neural sheaths of the internal auditory artery, and the seventh and eighth nerves, respectively.

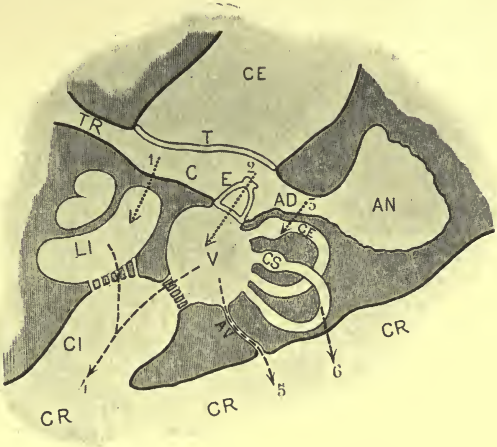

FIG. 236.—Diagram showing routes of infection from the antro-tympanic cavity to the internal ear, and from the internal ear to the interior of the cranium. (After Lermoyez.)

3. Invasion of the superior semicircular canal as the result of an extradural abscess in the middle fossa.
4. Infection within the internal ear by organisms in the general blood-stream.
5. Injuries, *e.g.* fractures of the base of the skull, foreign bodies in the ear.

The most frequent, and from the practical point of view the most important, pathway is by extension of disease through the inner wall of the middle ear. Organisms may gain entrance to the interior of the labyrinth as the result of erosion of some portion of its osseous framework, or through the fenestra ovalis when the stapes has become exfoliated, or through the annular ligament and *membrana secundaria* when involved in chronic middle-ear suppuration. The routes of infection, omitting localised erosions of the external semicircular canal, in order of relative frequency are :—

1. The fenestra ovalis.
2. The external semicircular canal.
3. The pars promontoria.
4. The fossula rotunda.

Pyogenic infection of the labyrinth is rarely the result of acute suppurative middle-ear disease. It is, in almost all cases, the outcome of prolonged infective inflammation of the middle-ear cleft, especially when complicated with erosion of its osseous framework, or with the presence of a cholesteatoma which from pressure-erosion gradually opens up the cavity of the internal ear.

Tuberculous disease of the middle ear or petro-mastoid with superadded pyogenic infection, which is invariable in such cases, leads at times to purulent disease of the labyrinth, and to the formation of numerous necrotic foci (necrosing tuberculosis).

Injury is also by no means an uncommon cause. Fracture of the base of the skull, the introduction of foreign bodies into the ear, clumsy and unskilful efforts made to extract them, and operative penetration of the labyrinth, intentional or accidental, during the performance of a radical mastoid operation are at times followed by pyolabyrinthitis.

Infective disease of the labyrinth has also been recorded as the result of a stapedectomy for chronic dry middle-ear catarrh.

An unskilful paracentesis of the membrana tympani for the relief of middle-ear suppuration has also been known to produce suppurative labyrinthitis. The most common traumatic causes are the unskilful use of instruments during operative procedures upon the outer labyrinthine wall, or during a curettement of the tympanic mucosa, especially in the neighbourhood of the stapedio-vestibular articulation.

Pyolabyrinthitis may be acute or chronic, while either form may be diffuse or circumscribed. Diffuse suppuration is prone to follow the entrance of pathogenic organisms into the vestibule, either by way of the fenestra ovalis or fossula rotunda, whereas localised suppuration is more frequently met with when the external semicircular canal has been slowly eroded by an infected cholesteatoma or tympanic granuloma. An acute diffuse labyrinthitis results also at times from what may have been for long a circumscribed and chronic process. Localised suppuration is frequently responsible for the formation of sequestra of various portions of the internal ear, *e.g.* the semicircular canals or the cochlea. Sequestration is more especially prone to take place as the result of an acute attack of post-exanthematous panotitis in children which has subsequently become chronic (Fig. 237). In such cases a sequestrum, consisting of the whole internal ear, has occasionally been exfoliated.

Morbid Anatomy and Pathology.—Suppuration of the labyrinth may be acute or chronic, primary or secondary, localised or diffuse.

Acute.—Acute primary infection is extremely rare. It may occur either as part of an acute specific fever, or as the result of traumatism involving a healthy labyrinth, or one whose capsule is already slightly involved in antro-tympanic disease.

In the early stage the membranous labyrinth loses its transparency and becomes opaque, and of a vivid red colour which rapidly extends to the endosteum and the bone itself. Granular degeneration of the lining epithelium takes place, and many leucocytes and lymphocytes appear among the hyperaemic vessels of the endosteum, eventually wandering into the perilymph and endolymph. Should there be a free opening into the bony canal, due to wound dehiscence or disease of the windows, blood-stained pus is found (but never in large quantities), varying with the nature and intensity of the infection. It soon completely masks the vestibular contents, and causes more or less disorganisation of the nerve terminals, but, according to West and Scott, was not seen in the semicircular canals of their cases. The writer has, however, seen it in two instances which were of seven and twelve days' duration respectively.

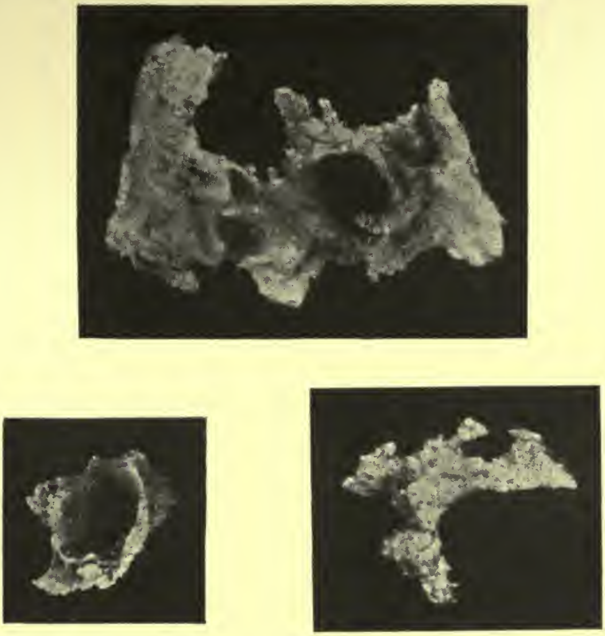

FIG. 237.—Sequestra removed from the internal ear by operation.

Should there be no exit for the pus, necrosis of the whole or part of the bony labyrinth will follow, especially in children, in whom it is so sharply defined and almost surrounded by cancellous tissue.

Extension of the process is seen as an infiltration of the perineural sheath (contained in the internal auditory meatus) by yellow or turbid fluid. From this situation and from the vestibular contents we have demonstrated such organisms as the *streptococcus, diplococcus catarrhalis,* and *meningococcus.*

Should free drainage be quickly established, the inflammation will subside without necrosis, but with permanent damage to function in degree proportionate to the duration, intensity, and extent of the lesion. Fibrous and osseous formations subsequently cause considerable narrowing and deformity of some portion of the labyrinth. Should granulation tissue follow and persist, small islands of necrosed or carious bone will probably be discovered.

Chronic.—Similar lesions occur in chronic infective labyrinthitis with the exception of necrosis. The bony capsule may be the first part attacked, either from the tympanum or from the cancellous bone which lies between the semicircular canals and the mastoid element, or more rarely, from that portion lying in front of it towards the apex of the pyramid. It is more likely to be circumscribed than in the acute form, unless it happens to be the sequel of such an invasion, since barriers of granulation tissue are frequent. In tuberculous disease especially, invasion of the labyrinth is very insidious and slow, since the attack may be made through the before-mentioned cancellous bone, and involve chiefly the semicircular canals with the corresponding portion of the vestibule, leaving the cochlea untouched. Should infection extend from the tympanum the lower turns of the cochlea and vestibule may be involved, leaving the apex apparently free.

In the course of a chronic suppuration of the middle ear a necrosed labyrinth sequestrum may be extruded, generally during the period of an acute or subacute exacerbation.

Infection from the tympanum may take place through several spots which are held to be specially vulnerable. They have already been enumerated on p. 482. The exact site will generally be indicated by a patch of granulations unless a circuitous route has been selected through the cancellous tissue beginning in the posterior sinus. The rôle played by cholesteatomata in erosion of the external semicircular canal is very well marked, much more so than penetration through either the promontory or the oval window (Fig. 238).

The most serious aspect of labyrinthitis, acute or chronic, is intracranial infection, which is obviously chiefly directed to the posterior fossa, and conveyed either by the peri-vascular or peri-neural lymph spaces surrounding the seventh and eighth nerves and the internal auditory artery. These complications will be exhaustively dealt with in other chapters.

The bacteria found in the labyrinth during chronic suppuration are practically the same as occur in the tympanum. A complete list will be found in the chapter devoted to aural discharges (p. 251).

There is one somewhat interesting fact in connection with the chronic form of inflammation, viz. that considerable destruction of the osseous wall on its tympanic aspect may take place with but little apparent damage to the membranous labyrinth. This may be explained by their each having a separate arterial supply, and there being no anastomotic connection between them (*vide* "Anatomy," p. 436).

Symptomatology.—In many cases of pyolabyrinthitis localising symptoms are entirely absent, the labyrinthine lesion being only detected during the performance of the radical mastoid operation.

In other cases, symptoms depend upon whether the whole or circumscribed portions of the internal ear are involved, and whether the process is acute or chronic. When the external semicircular canal is found open, or is opened unintentionally, labyrinthine symptoms are rarely found, but injury to or disease of the vestibule or cochlea is at once associated with specific symptoms. In other words, certain symptoms exist in all diffuse infections of the labyrinth, and certain others, varying with the particular part implicated, in localised disease.

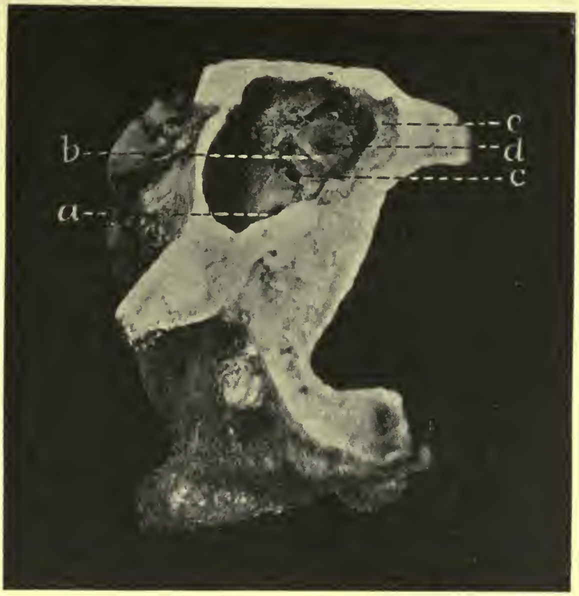

FIG. 238.—Temporal bone, showing erosion of canal for facial nerve, external semicircular canal and posterior part of vestibule from a case of pyo-labyrinthitis. *a*, Fossula rotunda; *b*, opened-up facial aqueduct; *c*, fenestra ovalis; *d*, erosion of external semicircular canal; *e*, erosion of wall of vestibule.

Circumscribed pain of a deep-seated boring character, and referred to the depths of the auditory meatus, is common. In many cases severe and persistent headache, referred to the vertex, the occiput, or the frontal region, is complained of.

During the formation of a sequestrum or during the process of its exfoliation, when it is usual to have an excessive production of granulation tissue and at times retention of pus, the pain is of a deep-seated and boring nature and is almost constant except in uncomplicated tubercle.

In acute infections the temperature is markedly raised, rising to 102° to 104° F., whilst the pulse-rate is correspondingly increased. In uncomplicated chronic pyolabyrinthitis the temperature and pulse-rate are about normal, except when an intercurrent infection is superadded, or when drainage is interfered with from an excessive growth of granulation tissue around a deeply-seated sequestrum.

Tinnitus is usually a very variable symptom. It is more common during the acute or subacute stage of the disease, and more especially when the lesion is mainly vestibular. It is usually high pitched, sharp, and shrill.

Vertigo is an almost constant symptom in suppurative infection of the semicircular canals or vestibule, but is not, however, met with in uncomplicated and localised disease of the cochlea. It may take place in a vertical, horizontal, or oblique plane. It may persist for days or weeks, or it may be transitory, and at the actual moment of examination may be conspicuous by its absence. It may be constant and of almost uniform intensity, or may occur in definite paroxysmal exacerbations. As a rule, a tendency exists to fall over to the side corresponding to the existing lesion, while the sensation of external objects moving from the affected to the sound side, is frequently present.

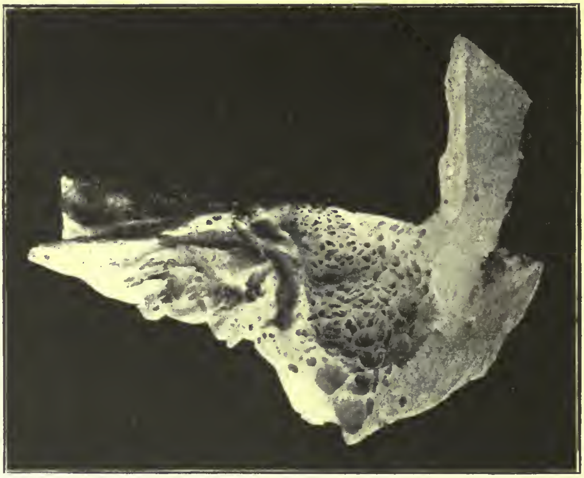

FIG. 239.—Large fistulous opening into external semicircular canal. Case of chronic suppurative otitis media with septic infection of labyrinth and extensive basal meningitis.

The sensation of vertigo may be present even when the patient is lying quietly in bed. It is, as a rule, aggravated by any undue exertion, by stooping, or indeed by any sudden movement. It is invariably aggravated by turning the head towards the affected side, by attempting to stand with the feet together and eyes closed, and by walking forwards or backwards with the eyes shut. The effort to stand upon one foot with the eyes closed is usually followed by a tendency to fall towards the affected side—Rombergism—whilst any attempt to walk forwards in a straight line is accompanied by peculiar swaying movements generally towards the affected side. Marked ataxic movements are not uncommon.

In tuberculous labyrinthitis vertigo is infrequent.

Vomiting is at times present in uncomplicated cases, but is more usually an accompaniment of meningeal or cerebellar infection.

Some amount of deafness is present in almost all cases, and is at times absolute and complete. In localised disease of the semicircular canal system there may, however, be no impairment of hearing. Its actual amount depends upon the duration, location, intensity, and extent of the initial lesion. The upper tone limit is more especially implicated; bone conduction is shortened, and Rinné's test is frequently negative upon the affected side. In cases of complete destruction of the labyrinth there is invariably absolute deafness upon the affected side. Hearing remnants are, however, present when labyrinthine destruction is incomplete. Although unilateral nerve deafness is an important symptom of pyolabyrinthitis, its absence does not necessarily mean that labyrinthine disease is not present, as the lesion may be quite superficial and localised to its outer wall.

Nystagmus is common, especially in cases of acute suppuration or in acute exacerbations of chronic disease. It may be transitory, and is thus easily overlooked. It may be vertical, horizontal, or rotatory. More commonly it is in the horizontal plane, and is easily detected when the patient looks towards the healthy side. In localised suppuration of the external canal it appears only when the eyes are turned away from the healthy side, and in localised erosion of the canal may be induced by compression of the air within the external auditory meatus by means of Politzer's bag or pressure upon the tragus with the finger (fistel-symptom); in diffuse suppuration it takes place in all positions the eyes may occupy. It is invariably accompanied by an inequality in the size of the pupils, that on the same side as the labyrinthine lesion being dilated.

Nystagmus due to labyrinthine infection becomes gradually less and less evident as the destruction of the internal ear becomes greater, whereas nystagmus of cerebellar origin increases with the progress of the disease. In addition, nystagmus, which at the commencement is present only when the eyes are turned to the healthy side, and subsequently changes to a nystagmus when the eyes are turned to the affected side, is pathognomonic of a cerebellar lesion.

In those chronic cases in which the progress of the disease is slow and insidious, and in which destruction of tissue is gradual and circumscribed by adhesions, the symptoms detailed above, although present, exist as a rule in a much less characteristic form. Any case of chronic suppurative middle-ear disease where progressive loss of hearing, accompanied by gradual contraction of the upper tone limit and diminution of bone conduction, is present should arouse suspicion as to a probable implication of the internal ear.

Prognosis.—In all cases of pyolabyrinthitis the prognosis, both as regards the risk to life and as to the loss of hearing power, is serious. Acute and diffuse infections are frequently fatal (15 to 20 per cent) owing to the development of acute basal meningitis. In the more circumscribed and chronic forms of the disease the danger to life is not so great, although the damage done to the auditory function is frequently severe and irreparable.

In chronic cases the main dangers to be anticipated are progressive osseous erosion and infection of the meninges and cerebellum. Pyolabyrinthitis of exanthematous or tuberculous origin is, as a rule, more destructive and more frequently fatal than that due to other pyogenic causes.

Terminations.—Acute diffuse pyolabyrinthitis may terminate in :—

1. Total destruction of the auditory function.
2. Sequestration of part or the whole of the labyrinth.
3. General blood infection.
4. Chronic disease.
5. Death.

Chronic pyolabyrinthitis may terminate in :—

1. Ossification of the affected area.
2. Caries of part or the whole of the labyrinth.
3. Erosion of bone and infection of the contents of the middle or posterior fossa.
4. Destruction of the static or acoustic segments of the internal ear.
5. Septicaemia or pyaemia.
6. Death.

Complications.—The most frequent complications are suppurative meningitis, serous meningitis with distension of the ventricles, cerebellar abscess, and septic thrombosis of the jugular vein.

In exceptional cases when the superior semicircular canal is the part principally involved, meningeal infection starting in the middle cerebral fossa or abscess of the temporo-sphenoidal lobe may supervene.

Infective organisms reach the interior of the calvarium, and almost without exception the posterior fossa, along already existing and natural paths of communication or as the result of erosion of some portion of the labyrinthine capsule, most frequently the upper or posterior bony canals.

In order of relative frequency these paths are :—

1. The peri-neural and peri-vascular sheaths of the auditory or facial nerves and vessels.
2. The aqueductus vestibuli with the consequent formation of an empyema of the saccus endolymphaticus and subsequent cerebellar abscess.
3. The aqueductus cochleae.
4. Erosion of the superior and posterior semicircular canals.

Treatment.—The treatment of pyolabyrinthitis is mainly surgical, an operation being called for when a functional examination reveals the existence of nerve deafness and symptoms of irritation of the vestibulo-canal system, and objective appearances found on exposing the middle-ear cavities point to the presence of extensive disease of the labyrinth. Should objective examination reveal merely the presence of localised disease of a semicircular canal, it is advisable to employ expectant treatment in the hope that the symptoms of irritation present before the operation upon the middle-ear cavities was undertaken may subside.

Symptoms indicative of an intra-cranial lesion demand, however, immediate exploration of the labyrinth.

When a movable sequestrum can be felt with a probe it is advisable to at once enlarge the existing fistulous tract leading to it and to remove it. If, on the other hand, a sequestrum is present but not movable, regular douching of the ear and the instillation of solutions of hydrogen peroxide or dilute mineral acids may be tried in order, if possible, to loosen it.

Exposure of the outer labyrinthine wall during the performance of the radical mastoid operation reveals at times the presence of osseous erosions whose existence had not been suspected beforehand. Such limited lesions, superficial erosions, and blind fistulae involve usually the outer portions of the labyrinthine wall, the membranous canals and the cochlea remaining intact. At the same time their presence is capable of giving rise to irritative symptoms, such as vertigo and nystagmus, although fatal results are not known to follow so long as the infection remains localised. The fact that the performance of the radical mastoid operation affords free drainage is of itself often quite sufficient to effect a cure without having recourse to scraping the infected bone; at other times, however, where the disease is more extensive and deeper seated, it is advisable to gently curette the softened area, without, however, actually opening the membranous canals. No operation on the labyrinth is entirely free from danger, and the greatest care should always be exercised not to break down protective barriers.

Careful investigation of any osseous erosion should always be made with a delicate and blunt-pointed silver probe to ascertain if by chance it leads into a deep seated cavity containing a sequestrum.

The existence of a dark shadow about the level of the semicircular ridge is, as a rule, indicative of extensive labyrinthine disease, and its importance is intensified if at the same time a fistulous tract is found leading through the pars promontoria, or if the stapes be found absent. In such cases extensive labyrinthine disease will be found present.

When clinical symptoms indicate the existence of a deep-seated pyo-labyrinthitis involving the static or acoustic segments of the internal ear, or both together, or palpation with a probe reveals the presence of a large and deep-seated sequestrum or carious patch, it is necessary to open up the internal ear upon a definite and well-defined plan, due regard being paid to the many important anatomical structures lying in immediate relationship with the outer labyrinthine wall.

The external semicircular canal situated invariably 3 mm. above the Fallopian aqueduct, and separated from it as a rule, by a small furrow in the bone, runs in an oblique direction, its anterior crus, 5 mm. in length, opening into the posterior wall of the vestibule. This opening is situated $1\frac{1}{2}$ mm. above the Fallopian aqueduct or $4\frac{1}{2}$ mm. above the *fenestra ovalis*, and is to be found in the course of a vertical line drawn through the posterior border of the oval window.

This crus is situated almost invariably above the facial nerve, although in a certain proportion of cases, estimated at about 12 per cent, it occupies a lower position, and is crossed by the facial nerve. Jansen, to whom the credit of having first opened the labyrinth is due, performs the following operation.

Jansen's Operation.—A complete and radical mastoid operation is first performed, minute attention being paid to freely exposing the facial spur, and the various landmarks on the outer labyrinthine wall. The posterior crus of the external canal is then located and opened. By working in a forward and upward direction its anterior crus is followed into the vestibule. The opening thus made is enlarged, great care being taken to avoid injury to the Fallopian aqueduct, which under normal circumstances is situated $1\frac{1}{2}$ mm. below the ampullary orifice of the external canal, to the dura mater and superior petrosal sinus above, and to the jugular bulb below.

The relation of the tympanic portion of the Fallopian aqueduct to the outer labyrinthine wall has already been described.

Neumann's Operation.—The inner antral wall is removed until the posterior semicircular canal is exposed. It is then followed forwards as far as its opening into the vestibule.

The stapes, if still present, is then extracted, and the bone between the lower margin of the fenestra ovalis and the upper margin of the fossula rotunda burred or chipped away, so as to freely open up the vestibule anteriorly.

Botey's Operation.—Botey opens the vestibule by taking as the immediate landmark the anterior crus of the external canal, opening it and enlarging the opening thus made anteriorly and superiorly. Should the stapes happen to be still *in situ* it is at once removed; if it has already disappeared, the fenestra ovalis is carefully enlarged and the posterior portion of the pars promontoria between the two fenestrae removed. In this way, an opening is made in front of and behind the aqueductus Fallopii.

To avoid injury to the facial nerve, Bourguet has introduced a special protector (Fig. 240) which is introduced into the fenestra ovalis, and made to cover the adjacent portions of the Fallopian aqueduct.

Hinsberg's Operation.—A complete and radical mastoid operation is first performed. The fenestra ovalis is opened by removal of the stapes if still present, and the opening carefully enlarged in an upward direction. A small stylet is now introduced into the vestibule as a guide, and the bony covering of the anterior crus of the external canal cut away until it is exposed to view.

Milligan's Operation.—After the performance of a complete radical mastoid operation, the petro-mastoid is opened in the triangular space between the posterior crus of the horizontal canal and the descending crus of the posterior canal. This small triangle is situated 4 mm. behind the highest point of the extreme convexity of the descending portion of the Fallopian aqueduct (Fig. 242). The opening thus made is enlarged upwards and backwards until the posterior canal is freely opened. By now working forwards along the posterior branch of the horizontal canal its anterior limb is approached and opened up until the interior of the vestibule is finally reached.

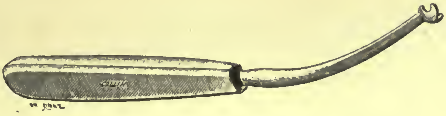

FIG. 240.—Bourguet's facial-protector.

A facial nerve protector (Fig. 241) is now introduced, and placed over the aqueduct in the form of a cap. The fossula rotunda is then located, and opened by means of a small electrically driven bur. The pars promontoria is subsequently cut away in an upward direction until the fenestra ovalis is reached, the stapes being removed if still present.

By means of another bur working vertically, the bone immediately under the aqueduct is cut away, so that finally, when the facial protector is removed, the aqueduct stands out like the arch of a bridge—end on, as it were, and facing the operator—between the semicircular canal system behind, and the cochlear system in front (Fig. 243).

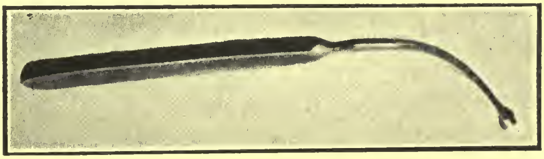

FIG. 241.—Milligan's "facial protector" for use during the performance of the "bridge operation."

Granulation tissue and purulent debris are now picked out with a delicate forceps (Hartmann), and a strip of gauze passed under the bridge so as to maintain free drainage. The cavity in the petrous bone is allowed to granulate from the bottom, so that complete obliteration of the previously infected labyrinth is effected.

The antro-tympanic cavity may subsequently be grafted or allowed to epidermise or to obliterate itself by the formation of healthy granulation tissue, the cutaneous lining of the anterior meatal wall as far as the annulus tympanicus being removed to effect this.

West and Scott's Operation.—Under the title of "*superior and inferior vestibulotomy*," the authors have described a method of reaching the interior of the labyrinth and effecting surgical drainage of its infected areas.

Superior Vestibulotomy.—The external arcuate eminence is first identified and removed, thus opening the outer crus of the external semicircular canal. This canal is now followed forwards above the facial aqueduct until its ampulla is reached and opened. The roof of the vestibule is removed by extending the operation forwards and upwards into the ampulla of the superior canal and the lower part of its ascending crus, and destroying the small pyramidal portion of very compact bone which lies between the proximal parts of the two canals. The operation may be extended by the removal of the three canals. This is effected by following the outer crus of the superior canal over its convexity until the crus commune of the superior and posterior canals is reached. The outer crus of the external canal is now attacked again and followed backwards and inwards until the posterior canal is reached. The deeper part of the external canal and the upper crus of the posterior canal are destroyed as far as the vestibule, the crus commune being opened up. The lower crus of the posterior canal is then followed

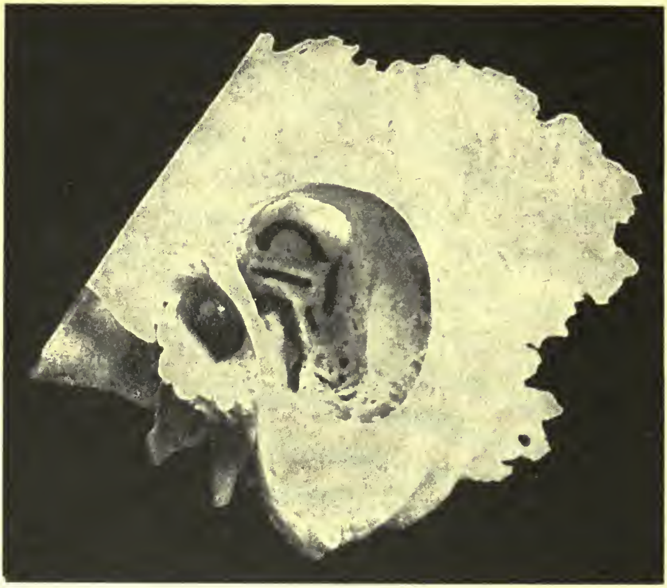

FIG. 242.—Temporal bone, showing relation of semicircular canals to one another and to the facial aqueduct.

downwards, forwards, and inwards to its ampulla, and to its opening in the floor of the vestibule.

Great care should be taken during the performance of this operation not to injure the thin layer of bone separating the superior canal from the dura mater lining the middle fossa and the bulb of the jugular vein which is in immediate relation with the deepest portion of the bony excavation.

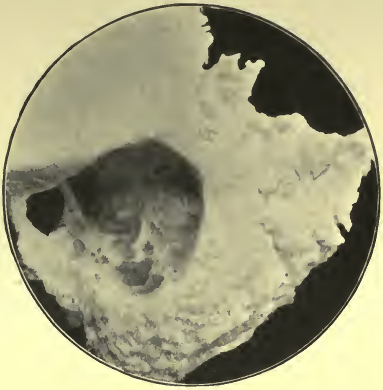

FIG. 243.—Temporal bone, showing completed "bridge" operation for the relief of pro-labyrinthitis.

Inferior Vestibulotomy.—In this operation the vestibule is opened below the facial nerve by the removal of its outer wall. The stapes, if still present, is first removed, and the bone between the fenestra ovalis and the fossula rotunda cut away. The operation may be readily extended so as to remove a part or the whole of the cochlea by working in a forward and upward direction from the opening already made in the outer vestibular wall. As any undue prominence (physiological) of the anterior or inferior bony meatal walls seriously interferes with a complete exploration of the cochlea, it is, in certain cases, advisable to remove the former wall as far as the annulus tympanicus and as much of the latter wall as is deemed necessary.

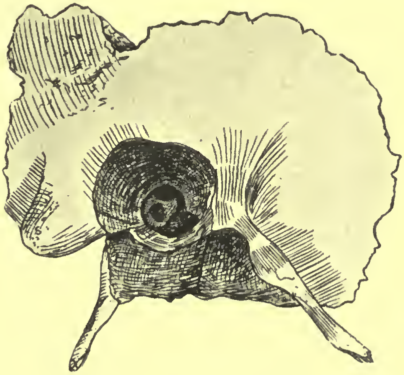

FIG. 244.—Inferior vestibulotomy.

The cochlea, now fully exposed to view, should be freely opened up, commencing the attack from its outer and posterior aspect. The modiolus, which is soon brought into view, should be destroyed by means of a bur, great care being taken to avoid injury to the knee of the internal carotid artery which lies in front and somewhat internally.

During the performance of an "inferior vestibulotomy" free escape of cerebro-spinal fluid, lasting frequently for several days, may take place, due usually to injury to the inner vestibular wall during curettement.

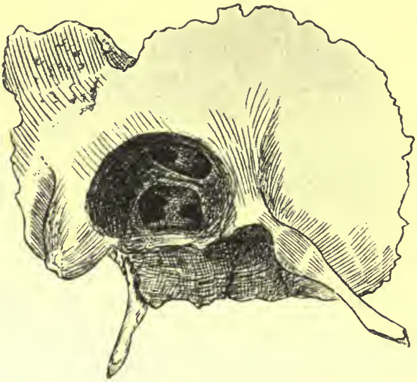

Fig. 245.—Double vestibulotomy.

Double Vestibulotomy.—In many cases, it is advisable and necessary to combine superior and inferior vestibulotomy with or without interference with the cochlea.

Complete extirpation of the labyrinth is called for in those cases of pan-labyrinthitis when both the static and acoustic segments of the internal ear are hopelessly affected by severe pyogenic infection, and as a means of approaching purulent foci situated deeply upon the posterior surface of the pars petrosa.

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CHAPTER XXXVI

DISEASES OF THE EAR IN RELATION TO GENERAL MEDICINE

By Purves Stewart, M.D., F.R.C.P.

In most cases which present auditory symptoms, the careful observer has no difficulty in referring them to an affection of some part of the auditory apparatus. But there are other morbid conditions whose etiology is primarily independent of any ear affection, and yet where auditory phenomena form a large part of the clinical picture, cases where symptoms such as deafness, tinnitus, or vertigo may occur, but are really symptomatic of an underlying intra-cranial lesion. Some of these may be briefly discussed here. They form a group where the otologist and the physician work usefully in conjunction.

1. **Gross Intra-Cranial Lesions associated with Auditory Phenomena.** (*a*) **Vascular Lesions.**—Almost any vascular lesion, whether embolism, haemorrhage, or thrombosis, may be associated with auditory phenomena, though, as a rule, the auditory symptoms are overshadowed by the general and focal signs of the intra-cranial lesion. In the majority of cases the signs and symptoms are those of hemiplegia, more or less complete, the extent of paralysis varying with the position of the lesion. In such cases aural phenomena may occur either as premonitory symptoms, or, less commonly, they may form part of the syndrome of focal disease.

Amongst the premonitory symptoms which may precede an attack of *cerebral haemorrhage* it is not uncommon to have giddiness, or, less frequently, tinnitus. In elderly people the occurrence of constant or paroxysmal giddiness in the absence of local causes in the ear sufficient to account for the symptom, should always be regarded with some caution. In such cases a most important diagnostic guide is found in the state of the blood-pressure.

Cerebral Embolism is rarely preceded by premonitory symptoms, auditory or otherwise; it occurs suddenly and without warning.

Cerebral Thrombosis occurs chiefly in cases of enfeeblement of the heart, and especially where there is arterial disease, which is often syphilitic in origin. Here, although the onset is more gradual than in cerebral haemorrhage, the antecedent symptoms are seldom auditory in type; perhaps a headache (which in syphilitic cases is frequently nocturnal) is the commonest antecedent symptom, accompanied, it may be, by transient aphasia or by transient weakness of the limb which may afterwards become hemiplegic, and sometimes by slight giddiness. The actual attack of thrombosis occurs at a time when the circulation is at its ebb; it is therefore commonest during sleep. The patient wakes up in the morning and tries to get out of bed as usual, but being already hemiplegic falls to the floor, so that the friends make the mistake of thinking that the attack came on at that moment. We are rarely called to see such cases until the hemiplegia has become *un fait accompli*, and the diagnosis presents little difficulty. The arterial blood-pressure in such cases is generally normal or subnormal.

Auditory symptoms may occur as part of the permanent syndrome of a hemiplegia, due to a cortical or sub-cortical lesion, chiefly in the form of *auditory aphasia*—so-called *word deafness.* The cortical auditory centre, according to modern views, is situated in the superior temporal convolution and in the adjacent transverse temporal convolution of Heschl—Flechsig's "auditory gyrus,"[1] on the upper or opercular surface of the temporal lobe. Lesions in this neighbourhood cause word-deafness. Such a patient is not actually deaf. He hears ordinary sounds, but he does not understand spoken words; they sound to him like an unknown tongue. It is not proposed here to discuss exhaustively the subject of word-deafness, but a few of the more important points will be indicated.

Sub-Cortical or Pure Auditory Aphasia, where the lesion is in the white matter, leaving the cortical centre intact, is extremely rare; in fact, some observers deny that it occurs. Such a lesion simply blocks the way in for spoken words; the patient is word-deaf, *i.e.* he is unable to understand what is said to him; he is therefore unable to repeat spoken words or to write from dictation. But inasmuch as the auditory word-centre is intact, he still possesses his memories of a spoken speech, and therefore spontaneous speech is perfect. Moreover, his visual word-centre being intact, he can read, and, in fact, his only means of receiving messages from other people is by reading. The other and commoner variety of word-deafness is *cortical word-deafness*, in which the auditory centre itself is damaged, and therefore the auditory memories of spoken words are destroyed. In such a case, in addition to the symptoms just mentioned: inability to understand spoken words, or to repeat them, or to write them from dictation, the processes of internal speech and thought are impaired, so that the patient makes mistakes both in speaking spontaneously and in reading aloud. He also makes mistakes in writing, especially in spelling. He may talk volubly, but tends to confuse his words and syllables, and in a severe case may talk an unintelligible jargon. Word-deafness renders the patient unaware of his own mistakes. The extent of word-deafness varies according to the completeness with which the auditory word-centre is destroyed. In a slight lesion, the only disability may be that of naming objects, the patient still retaining the faculty of expressing abstract ideas. Thus a partially word-deaf patient when shown a knife may be unable to name it aloud, but say, "it is for cutting." Or partial word-deafness may simply cause the patient to confuse his words, and to say one word when he means another: "paraphasia." Word-deafness rarely remains permanent and complete; a certain degree of recovery generally occurs, possibly from compensatory functioning of the auditory word-centre in the opposite hemisphere.

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[1] *Neurologisches Centralblatt.*, 1908.

Word-deafness depends solely on the anatomical position of the lesion. The pathological cause of the lesion is of no focal significance; it may occur equally from embolism, haemorrhage, or thrombosis. It is not uncommonly met with as a premonitory transient phenomenon in cases which, after a few hours or days, subsequently develop a right-sided hemiplegia with aphasia.

Intra-pontine vascular lesions of the lower part of the pons may produce nerve-deafness from implication of the auditory nuclei and of the intra-pontine portion of the eighth nerve. Bilateral lesions in this region are generally fatal, but a small unilateral lesion (more often a small patch of thrombotic softening than a haemorrhage) produces characteristic clinical phenomena owing to implication of adjacent sensory or motor tracts. At the time of onset of symptoms the patient commonly has severe vertigo which may persist for weeks or longer. It is observed that he has nerve-deafness on the affected side, and sometimes nystagmus on turning the eyes towards the side of the lesion. But what is most characteristic is the presence of analgesia and therm-anaesthesia on the opposite side of the trunk and limbs (not the face, which is supplied by the trigeminal nerve which is above the level of the lesion), without loss of tactile sensibility. This "dissociated anaesthesia" of the opposite half of the body is due to implication of the paths for pain and temperature, which course along the lateral margin of the pons close to the auditory nuclei, in the near proximity of the ponto-cerebellar angle. If the lesion extends farther towards the middle line so as to implicate the pyramidal tracts, we may have in addition motor weakness of the opposite arm and leg.

Transitory vertigo and nystagmus may also occur as premonitory signs of a threatened pontine thrombosis, a condition which is often syphilitic in origin. The writer remembers a severe case in a medical man of forty-four, in whom there developed intense vertigo, with rotatory nystagmus unaccompanied by deafness. The spinal fluid withdrawn by lumbar puncture showed the characteristic lymphocytosis of cerebro-spinal syphilis and under anti-syphilitic treatment all the symptoms rapidly cleared up.

(*b*) **Meningitis.**—Cortical meningitis rarely produces either deafness or word-deafness. On the other hand, basal meningitis, especially when it implicates the membranes in the ponto-cerebellar angle where the auditory nerve enters the pons, is frequently associated with auditory symptoms in the form of nerve-deafness or tinnitus, sometimes combined with a degree of facial weakness on the same side due to implication of the neighbouring trunk of the facial nerve. Other cranial nerves may also be affected according to the distribution of the meningitis at the base of the brain.

The diagnosis of meningitis is fully discussed elsewhere (p. 378).

Amongst the sequelae of meningitis it is not uncommon to have nerve-deafness, unilateral or bilateral, especially after posterior basic meningitis in children. The pathological cause of such nerve-deafness is most frequently a diffuse inflammation of the labyrinth. The deafness usually comes on acutely during the first or second week of the meningitis, and if the child be under the age of six years he may lose the power of speech and become a deaf-mute. Not uncommonly such a patient becomes mentally slow and stupid, an acquired deaf-mute in this respect being unlike the congenital deaf-mute, who is often bright and clever. Deafness due to meningitis is usually recognised by the history of an antecedent acute illness with symptoms including headache, fever, delirium and head-retraction, and by the absence of signs of old middle-ear disease.

We must carefully distinguish deaf-mutism from idiocy, whether congenital or acquired. An imbecile child is speechless, not because he is deaf, nor because of any articulative difficulty, but simply because he has no ideas to express.

(*c*) **Intra-Cranial Tumours.**—Intra-cranial tumours produce two classes of signs and symptoms—first, *general symptoms* of intra-cranial pressure, symptoms independent of the site of the tumour; and, secondly, *focal symptoms*, which depend on the particular part of the brain which happens to be implicated by the growth. Space does not permit a full discussion of the general symptoms of intra-cranial tumour. Suffice it to remind the reader that the most important are headache, optic neuritis, vomiting, generalised convulsions, giddiness, slowing of the pulse, etc. Attacks of giddiness are often complained of in cases of brain tumour. Sometimes these are merely indescribable feelings of confusion; in other cases there is a true vertigo or uncertainty in equilibration. Vertigo is specially early in onset and intense in degree in tumours which implicate the cerebellum, the cerebellar peduncles, and the corpora quadrigemina, and in them it is often associated with the motor phenomenon of a reeling or staggering gait.

Tumours of the cerebral cortex rarely produce auditory symptoms of a focal character. Only a few cases of tumour implicating the temporal lobe on the left side have been associated with word-deafness. In such cases the lesion is in the neighbourhood of Heschl's transverse temporal gyrus on the Sylvian surface of the temporal lobe, or in the adjacent first temporal gyrus. But only temporal tumours are devoid of focal symptoms, and only produce symptoms of pressure on adjacent parts. Another region of the brain where tumours may cause auditory phenomena is that of the corpora quadrigemina. The posterior corpus quadrigeminum, it should be remembered, is a subcortical auditory centre; hence, if it is destroyed, we may have deafness in the ear of the opposite side.

Such cases are recognised by the other phenomena of quadrigeminal disease, notably by the presence of characteristic ocular signs consisting of more or less symmetrical paralysis of the third nerve nuclei. We usually note a bilateral ptosis with weakness of upward and downward movement of the eyes and feebleness of convergence. If the adjacent superior cerebellar peduncle be implicated by the growth there is giddiness, nystagmus, and cerebellar ataxia, while if the external geniculate body or optic radiations be involved, there is a corresponding hemianopia.

Cerebellar tumours are the commonest of all intra-cranial growths, and amongst their focal symptoms auditory phenomena play an important part. The outstanding symptoms of cerebellar growths are vertigo, a reeling gait which is uninfluenced by closing the eyes, nystagmus, and optic neuritis of early onset. We have to distinguish between tumours of the lateral lobe and those of the vermis or middle lobe; moreover, in lateral lobe tumours we must differentiate between intra- and extra-cerebellar growths.

Tumours of the lateral lobe, whether they be intra- or extra-cerebellar, produce symptoms in the arm and leg on the same side as the lesion, consisting in weakness and ataxia on voluntary movement more marked in the arm than in the leg. Sometimes the upper limb exhibits a slowness or what is called *dokokinesia*, a term applied by Babinski to rapid alternate pronation-supination movements of the forearm. In cases of lesion of the lateral lobe of the cerebellum this movement is performed slowly and awkwardly — *dis-diadokokinesia* — when compared with the limb of the opposite side. Together with this, the upper and lower limbs on the affected side are sometimes unnaturally steady when held actively extended in the air, this phenomenon being exhibited best in the lower limb. In lateral lobe tumours the patient if he stands on one leg does so less securely on the affected side. He lurches or reels in walking, sometimes lurching towards the side of the lesion, sometimes away from it. Conjugate movement of the eyes towards the side of the lesion is often weak, and may be accompanied by horizontal rhythmic nystagmus, which is coarser on looking towards the affected side. The patient has also a subjective sensation of vertigo, in which surrounding objects seem to rotate towards the side opposite from the lesion. The condition of the deep reflexes is inconstant; they may be increased, diminished, or exaggerated in the limbs of the affected side. Sometimes the patient holds his head in a characteristic posture, tilting the ear towards the opposite shoulder and turning the face towards the side of the lesion.

Extra-cerebellar tumours most frequently arise from the sheath of the auditory nerve, in the angle between the pons and the lateral lobe of the cerebellum. Such tumours are, therefore, frequently associated with nerve-deafness, more or less complete, on the affected side, usually accompanied by tinnitus. If the adjacent facial nerve be implicated by pressure or infiltration, as is not uncommon, we then have paresis of the facial muscles, upper and lower, a sign of the utmost localising value when present. Less commonly other cranial nerves on the same side, such as the fifth or sixth, may be affected, with corresponding sensory and motor symptoms. If the growth be such as to compress the pyramidal tracts within the pons, there may be exaggeration of the deep reflexes on one or both sides, together with an extensor type of plantar reflex; but this is by no means constant.

Intra-cerebellar tumours of the lateral lobe differ from extra-cerebellar tumours in the fact that, as a rule, they are unassociated with deafness. Also they are less frequently accompanied by signs of involvement of other cranial nerves; nor do they usually cause signs of pressure on the pyramidal tracts.

Tumours of the vermis or middle lobe show the general symptoms of cerebellar growth, viz. vertigo, reeling, and nystagmus, but without preponderance of ataxia on either side or any inequality in the degree of *dis-diadokokinesia* until later, when the growth may extend into one or other lateral lobe. In middle-lobe tumours there is a tendency to fall forwards if the growth is at the anterior end of the vermis, or to fall backwards if it is situated posteriorly.

Tumours of the pons might theoretically be expected to produce auditory phenomena from implication of the auditory nuclei or nerves. Clinically, however, auditory symptoms are rare, or, if present, they are overshadowed by the more obvious signs of paralysis of the nuclei of the fifth, sixth, and seventh nerves, together with motor weakness of the limbs from affection of the pyramidal fibres, and with sensory loss if the great sensory tracts are implicated.

DEGENERATIVE DISEASES: TABES, DISSEMINATED SCLEROSIS, ETC.

(*d*) In **Tabes dorsalis** any of the cranial nerves may undergo primary degeneration. Those most usually affected are the optic nerves and the various ocular nerves (3rd, 4th, or 6th). The auditory nerve is less frequently attacked by the tabetic process, but now and then we do meet with cases of nerve-deafness, apparently due to primary atrophy of the cochlear fibres of the nerve, analogous to the atrophy which is fairly common in the optic nerves. Such cases exhibit progressive nerve-deafness, sometimes of rapid onset. Tabetic atrophy of the auditory nerves is usually bilateral, and may occur early in the course of the disease long before the other symptoms, such as lightning-pains, ataxia, etc., have become sufficiently prominent to attract attention. The diagnosis is made by thorough examination of the sensory, motor, and reflex functions, and valuable corroborative evidence of the tabetic nature of the nerve-deafness can be obtained by examination of the cerebro-spinal fluid, which shows the characteristic enormous lymphocytosis of the disease.

Disseminated sclerosis rarely produces nerve-deafness—much less frequently than in tabes; but, on the other hand, vertigo is a fairly common symptom, even in the early stages of the disease. There is no evidence that the early, often transient, vertigo of disseminated sclerosis is due to direct implication of the vestibular nerves or of the intra-pontine nuclei. More probably it is the result of patches of disease in various parts of the cerebellum. Of course, both in tabes and in disseminated sclerosis we may have vertigo, due to non-auditory causes, *e.g.* an ocular vertigo due to diplopia. This condition is readily recognised by careful routine examination.

Epilepsy.—In epilepsy auditory phenomena are occasionally met with as part of the initial aura ushering in the fit. Vertigo is a fairly common aura in epilepsy, but sensations of giddiness may arise from so many other conditions besides lesions of the auditory centres or tracts that it is of comparatively little diagnostic value. But occasionally cases are met with in which subjective sensations of sound initiate the fit. Sometimes these consist of a sudden deafening noise which coincides with the patient's loss of consciousness; in other cases more elaborate auditory sensations occur, such as the sound of bells, or, least common of all, hallucinations of voices or articulate words. Such aurae, when present, are of special diagnostic importance, and indicate that the cortical auditory centre is the area where the epileptic explosion starts.

Hysteria.—The auditory functions may suffer in two opposite ways in hysteria. First, we may have *hysterical deafness.* This is more often unilateral than bilateral, and it may be partial or total in degree. The symptom does not occur alone, but is always associated with other hysterical phenomena; for example, we may find diminution or absence of smell and taste, and more particularly concentric contraction of the visual field, all on the same side as the hysterical deafness. In most cases there is also present a degree of cutaneous hemi-anaesthesia on the same side of the body. Such combination of unilateral affection of special senses and of cutaneous sensibility is pathognomonic of hysteria and does not occur in any organic disease. In many cases hysterical deafness comes on suddenly after some emotional or psychical shock. Nystagmus does not occur in pure hysteria.

Secondly and less frequently, we may meet with *hysterical hyperacousis or hyperaesthesia of hearing* where sounds seem abnormally loud. This condition, like hysterical deafness, is rarely bilaterally symmetrical, but is usually more marked in one ear. Here, again, the co-existence of other hysterical stigmata, together with the absence of evidence of organic mischief sufficient to cause the symptoms, will usually enable us to arrive at a correct diagnosis.

Neurasthenia.—In neurasthenia, auditory phenomena are rarely a prominent feature in the symptomatology. Deafness from mere neurasthenia is excessively rare. Occasionally, however, in addition to the multiform aches and pains of which the neurasthenic patient complains, there may be tinnitus or vertigo.

Neurasthenic tinnitus is usually of the pulsating type, synchronous with the pulse, and is chiefly complained of when the patient lies awake at nights. Neurasthenic vertigo may be constant and slight in degree, or, more frequently, paroxysmal. The paroxysms of giddiness are generally excited by some trivial cause, such as emotional excitement, an attempt at physical or mental exertion, or by physical examination not only of the ear, but sometimes of other parts of the body. The diagnosis of neurasthenic vertigo is made by the exclusion of local causes in the auditory apparatus sufficient to produce the symptom, and by the presence of the other symptoms of neurasthenia, generally multifarious and related by the patient with great wealth of detail. Nystagmus does not occur in uncomplicated neurasthenia.

In certain cases of hysteria and of neurasthenia, and especially when the symptoms follow an injury, or are the subject of an action for damages, we have always to bear in mind the possibility of malingering. It is scarcely necessary to remind the reader that both hysteria and neurasthenia are real diseases, as real as fracture of a bone or a cerebral haemorrhage. Want of recognition of this fact leads to the erroneous idea, too frequent both in the legal and in the lay mind, that to state that a patient is hysterical or neurasthenic is synonymous with accusing him of shamming. Such is not the case. Traumatic neurasthenia is a serious affection which may require prolonged and careful treatment before recovery takes place. Occasionally, however, we meet with cases of deliberate attempt at fraud, when the patient, after an alleged injury, complains of all sorts of symptoms, auditory or otherwise, which he attributes to the accident which is the basis of litigation. Here it behoves the medical witness to preserve a judicial mind. A good rule to follow, when invited to examine a patient with a view to giving evidence as to the nature of his symptoms, is to state beforehand that one's opinion may or may not be in favour of the side which calls one in. A careful report of the patient's condition should then be drawn up. If this happens to be adverse to the opinion of the party on whose behalf it was made, the logical course for that party is to abstain from placing the medical expert in the witness-box.

Successful simulation, however, is a much more difficult matter to carry out than the malingerer realises. Careful examination by the physician and the aurist invariably reveals gross contradictions and falsities in the alleged symptoms, together with absence of evidence of true organic mischief.

(*e*) **Insanity.**—Deaf patients are more liable to insanity than ordinary people. We have already referred to certain cases of deaf-mutism where the patient undergoes mental deterioration. Apart from such cases, the presence of deafness favours the onset of auditory hallucinations, and even a sane person who happens to be deaf sometimes suspects that bystanders, taking advantage of his infirmity, are talking about him. The transition from this condition to an insane delusion is thus comparatively simple.

Auditory *hallucinations*, where sounds are heard by the patient without any external cause of auditory stimulation being present, and auditory *illusions*, where real sounds are misinterpreted by the patient, *e.g.* where the sound of a water-tap is thought to be voices whispering remarks about the patient, occur in various forms of insanity. The commonest form of auditory hallucination consists of voices heard by the patient, sometimes so loudly as to drown the voices of real persons speaking to him; it may be necessary to shout to such a patient in order to make oneself heard. Other common hallucinations are those of church-bells and musical instruments or orchestras. As a rule, the presence of auditory hallucinations makes the prognosis less favourable than in other forms of hallucination. Insane patients who are also deaf are specially liable to auditory hallucinations. In cases of such hallucinations it is useful to make the experiment of getting the patient to stop his ears for a moment and to notice whether the auditory hallucinations then disappear or not. If they do not disappear, the prognosis is rather better, since one is more likely to persuade the patient that the noises heard are hallucinations, and not due to external stimuli.

Apart from hallucinations and illusions in insane patients, the auditory acuity is sometimes of diagnostic value, tested by noting the distance at which a ticking watch can be heard in each ear. Auditory acuity is not uncommonly diminished in cases of dementia and in certain cases of general paralysis of the insane. In fact, in some cases of the latter disease, deafness is noticed by the patient's friends as one of the earliest symptoms.

CHAPTER XXXVII

INJURIES OF THE INTERNAL EAR

Injuries affecting the Internal Ear.—The internal ear may be injured as the result of direct or indirect violence.

Direct injury occurs occasionally from the introduction of a foreign body into the meatus and from its passage thence into the internal ear, *e.g.* pencil, hair-pin, bullet, etc., also occasionally as the result of operative procedures, *e.g.* slipping of a chisel, bur, etc.

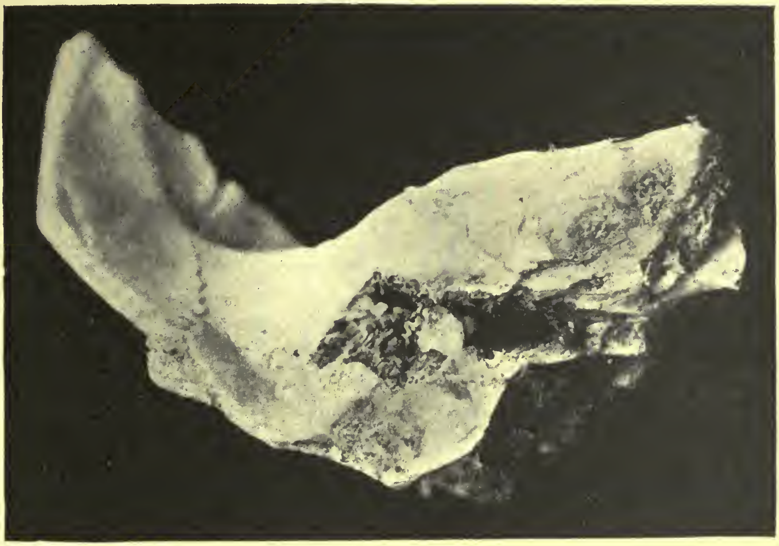

FIG. 246.—Temporal bone from case of fracture of the base of the skull, showing the line of fracture running by the side of the internal ear and through the middle ear.

In such cases there is a risk of septic labyrinthitis ensuing.

Indirect injuries are due to falls or blows upon the head or to the effects of concussion, *e.g.* artillery rifle practice, shooting with sporting guns, mine and gas explosions, also prolonged and excessive exertion.

In cases of fractured base the line of fissure most frequently runs by the side of the internal ear across the tympanic cavity, and through the upper wall of the auditory meatus (Fig. 246). It may stop short of the middle ear, or involve the middle but not the external ear. The vessels entering the internal ear through the internal auditory meatus are frequently torn as they pass through the *porus acusticus*. Hence haemorrhage into the internal ear (cochlea and vestibule) is by no means uncommon. In cases of severe concussion haemorrhage may take place into the internal ear without the existence of any fracture. In all such cases the immediate effect is the production of severe deafness accompanied by high-pitched tinnitus, vertigo, and inco-ordination of movements.

Recovery to a certain extent takes place even in those cases where presumably there had been a haemorrhage which had become gradually absorbed.

CHAPTER XXXVIII

DEAF-MUTISM

Deaf-Mutism is a condition in which the function of speech is absent as a result of more or less complete absence of hearing power.

It may be conveniently, yet somewhat arbitrarily, divided into congenital and acquired.

The term *congenital* is applied to that form in which the power of hearing is absent at birth, consequently speech can only be taught by the aid of some sense other than the auditory.

By *acquired* is meant the absence of speech due to the loss of hearing power in one whose auditory apparatus has at one time been functional. It is important that a clear distinction should be made between the two forms for purposes of prognosis and treatment.

Aetiology.—There can be little doubt but that heredity and consanguinity of parents are indirectly responsible for the *congenital* type. Direct transmission following the union of two deaf-mutes is rare, since such alliances are, as a rule, not fertile. Therefore, one must consider two conditions as causing this form, viz. degenerative changes involving the cochlear nerve-mechanism occurring *in utero*, and a constitutional deaf-mutism due to consanguinity so often associated with cretinism.

Like other nerve diseases, it may be due to indirect ancestral inheritance. Inter-marriage in families with an ancestral history of deaf-mutism will produce occasional deaf-mutes.

Acquired deaf-mutism may be due to: (1) Diseases affecting the auditory apparatus (primarily); (2) intra-cranial disease, such as epidemic and tubercular meningitis, hydrocephalus; (3) specific fevers, syphilis, rickets, goitre, etc.

Pathology.—The histological lesions of *congenital* deaf-mutism are essentially those of degeneration of the cochlear nerve, its ganglia, and its terminations central and peripheral. In three specimens shown by Gray,[1] Corti's organ, the cochlear nerve, its ganglion, and its peripheral terminals were completely degenerated, while the vestibular division of the nerve and its terminals was unaffected. There was general enlargement of the labyrinth, probably owing to increased intra-labyrinthine pressure upon its early cartilaginous framework—such as might be occasioned by purely intra-labyrinthine changes, or by intra-cranial pressure acting through the cochlear aqueduct (the subarachnoid fluid and perilymph having free communication)—an explanation which was further supported by a marked depression of Reissner's membrane. The external and middle ears, as in most other cases, were perfectly normal. Occasionally, however, the tensor tympani muscle is found atrophied with more or less anchylosis of the ossicular joints.

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[1] *R.S.M. Trans.*, Jan. 1910.

Mott has found microscopic degeneration of the cortical cells of the auditory area. Thus the degenerative changes seem to be essentially confined to the cochlear nerve, which is not surprising in view of its development, the vestibular nerve entirely escaping. Whether this is so in those cases which originate from meningitis involving the whole trunk of the nerve has yet to be proved.

Anatomical evidence thus shows the congenital form to be a purely local disease confined to the cochlear element. Still, evidence of coincidental deformity of other parts of the auditory apparatus is not wanting, such as complete atresia of the meatus, with obliteration of the antro-tympanic cavity and absence of the tympanic ring and membrane. With the exception of a few recorded instances of diminution in the size of the bony labyrinth, the general enlargement already referred to seems to be the chief change occurring in that structure.

The exact nature of the pathological changes which constitute the degenerative lesion is not clear. Some authorities describe simply atrophic changes, while others have recorded a lymphocytic infiltration and sclerosis suggestive of an inflammatory process. In all cases the nerves and their ganglia quite lose their histological identity.

Such are the chief lesions found, although many others have been described. There is, however, some hesitation in accepting some of them as purely congenital, such as malformation of the middle ear, osseous occlusion of the windows, changes in the cochlear duct, collapse of the membranous labyrinth with imperfect development of its sensory epithelium, the presence of calcareous deposits, excessive pigmentation, and hyaloid bodies, and, lastly, partial or imperfect development of the labyrinth.

In the *acquired form* the various changes are mainly due to labyrinthine lesions occurring secondarily to the acute and chronic middle-ear troubles of early life. Though the labyrinth and its nerve-supply may be primarily involved, deaf-mutism is generally the result of an involvement occurring during the first four years of life (according to some authorities, however, it may occur even up to seven years). Occurring at a later period it is less common.

As a result of acute and chronic suppuration of the middle ear the labyrinth and its contents share the adjacent disease either by direct extension through the bony capsule, or by infection through the different vasculo-nervous channels. It seems particularly susceptible to diphtherial and scarlatinal infection. That this variety of deaf-mutism may be due to cerebro-spinal meningitis by extension to the labyrinth is highly probable. To the chronic non-suppurative or oto-sclerotic form deaf-mutism has been attributed, but this lesion is rare in early life.

Complete exfoliation of the labyrinth due to acute osteo-myelitis and the diphtheritic form of panotitis is, in infants, followed by deaf-mutism. In the latter form the original inflammatory products are later converted into osseo-sclerotic elements indicating a considerable endostitis of the labyrinth. It is in these secondary or acquired forms that pathological changes are found to involve the vestibule and semicircular canals, which, as has been shown, are decidedly rare in the congenital type.

It would be tedious to describe in detail all the various anatomical lesions found in acquired deaf-mutes; they will therefore be briefly summarised:—

Osseous Labyrinth.—Caries and necrosis, sclerosing endostitis, simple thickening of endosteum, hyperostosis.

Membranous Labyrinth (all or in part only).—Complete replacement by fibro-plastic deposit, excessive pigmentation, calcareous deposits, colloid, fatty, and other degenerations of epithelium.

Acoustic Nerve and Ganglia.—Sclerosis and atrophy.

Brain.—Degeneration of cortical cells in the auditory area (Mott), chronic pachy-meningitis.

Middle Ear.—All varieties and conditions of chronic and recurring suppurative inflammation, ossicular anchylosis, non-suppurative sclerotic changes, osseous occlusion of windows, and deposits in other parts.

External Ear.—Bilateral sclerotic atresia of meatus.

Some few Points in Diagnosis.—In view of the restriction of pathological lesions to the cochlear element in congenital malformation, and the frequent involvement of both cochlear and vestibular systems in the acquired form, the employment of Bárány's caloric test is of special value in differential diagnosis.

Recorded observations so far indicate that ampullary reaction is fairly normal in most congenital cases, but in about 50 per cent of acquired is either lost or impaired.

Differential Prognosis.—Many cases of congenital deaf-mutism will be found to possess a residue of undegenerated portions of the cochlear nerve and its terminals. Sometimes this is gradually lost, but fortunately in many it may even improve, and may serve as the foundation upon which most successful teaching may be based. Therefore, as a rule, prognosis is much more hopeful in congenital than in acquired forms; in the latter the lesion is more likely to be progressive.

In the acquired form it will depend upon the age of the patient at the onset of total deafness, and on the nature and extent of the lesion. Many authorities consider the outlook of scarlatinal and diphtheritic cases exceptionally bad, and Politzer is emphatic as regards meningitis.

The outlook in relation to mental changes is by no means bad in congenital cases, and nothing can justify their being regarded as or classified with degenerates. Many congenital deaf-mutes are exceptionally intelligent and that brightness becomes strikingly developed in the course of training. A certain amount of apparent moroseness and desire to shun their fellows is due more to shyness and disappointment in making themselves understood than to any mental deficiency. This is seen in all varieties of deaf patients, especially those who become deaf late in life, and are unsuccessful with speech and finger reading.

CHAPTER XXXIX

AURAL DISEASE AND LIFE INSURANCE—SIMULATED DEAFNESS

Aural Disease and Life Insurance.—The relation of ear disease to life insurance is a very difficult subject to discuss, as it involves so many considerations. The personal equation is one.

For instance, a patient with evidence of long-standing suppuration of the middle ear with occasional labyrinthine disturbance, who obstinately refuses to undergo radical treatment, should not be accepted at any rate, but after successful treatment and an interval of freedom from all symptoms, may be accepted with a moderate penalty attached to the annual premium.

It would be extremely unfair to establish an inelastic standard of fitness or unfitness, particularly in view of the rapid progress of otological surgery.

Still some indication of a standard of fitness may be suggested by a consideration of the following points. A history and existence of labyrinthine disease, however obscure, should always be penalised, for although the disease itself may not directly shorten life, it may do so indirectly (Swift).

Absolute and unqualified rejection—

1. Unequivocal signs of syphilis, tubercle, lupus, or neoplasm in the ear itself.
2. Exostoses and intractable stenosis of the meatus, with or without existing discharge.
3. All suppurative middle-ear cases with vestibular complications.
4. Evidence of caries or necrosis of any part of the temporal bone, with or without facial paralysis.
5. Any form of aural trouble associated with an existing or past leukaemia, tuberculosis, syphilis, and arterio-sclerosis.
6. Whenever the aural discharge is accompanied by disease of the nasal accessory sinuses.
7. All primary or secondary infections of the labyrinth with or without history or evidence of intra-cranial disease.

Penalised acceptance may be advised in—

Those who have undergone the radical operation, and in whom there has been no recurrence of any symptoms whatever for a period of two or three years, and no evidence of cholesteatomatous accumulation or sepsis. But there should be some hesitation in accepting, even with an increase of premium, any such patient who suffers with recurring attacks of eczema.

Deferred consideration pending complete cure should be applied to—

1. All cases of acute and chronic eczema of meatus and auricle, especially those showing a tendency to stenosis.

2. Subacute and acute primary muco-purulent inflammation of the middle ear, especially those cases accompanied by nasal and naso-pharyngeal obstruction.

While it is extremely difficult to fix any arbitrary distinction which is impartial alike to the insurance company and to the proposer—for there will always be some difference of opinion even among experts—the foregoing remarks may help as a guide to conclusions, which should, however, always be supplemented by careful examination of discharge and other material at the hands of a pathologist especially experienced in such work.

Simulated Deafness.—Simulated deafness, either partial or total, is not so frequently attempted in this country as in countries where military service is compulsory. It is at all times difficult to detect, especially when the patient is intelligent and the modus well planned. Total bilateral deafness is not so frequently simulated as is unilateral total deafness or bilateral hardness of hearing. Where a genuine although partial defect of hearing is present it is generally exaggerated. To increase the difficulties of detection foreign bodies—caustic fluids and the like—are at times introduced into the ear, and the walls of the meatus and even the membrana tympani purposely injured. In all cases a careful examination of both ears, and of the pharyngeal, nasal, and naso-pharyngeal cavities, should be made to ascertain if any pathological lesion likely to cause an impairment of hearing is present.

In cases of unilateral simulated deafness the patient should be blindfolded and the good ear stopped up. Careful measurements of the existing hearing power, by means of the voice, watch, and acoumeter, should be made, and the tests repeated upon several occasions. In this way discrepancies in the replies given are frequently observed. Marked differences in the distance at which the watch is heard, when noted at the same sitting, should arouse suspicion.

When total deafness is simulated the difficulties of detection are greatly enhanced. Taking the patient when off his guard and addressing him in a loud voice, making disparaging remarks about him in his presence, while carefully watching his features, and attempting to rouse him suddenly out of his sleep by means of some loud noise serve at times to reveal the deception.

When total unilateral deafness is feigned, a useful method is to employ a binaural stethoscope (Coggin), one limb of which has previously been plugged with cotton wool or a piece of cork. The ends of the stethoscope are now inserted into the patient's ears, the end of the plugged limb being inserted into the good ear, and words are spoken into the mouthpiece. These words the patient generally admits he hears. The end of the plugged limb is now removed from the good ear and the ear closed tightly with the finger. The words are again spoken, and this time are said by the patient not to have been heard, knowing as he does that the good ear is closed and that the stethoscope is only in the ear in which he simulates deafness.

An ingenious test has been devised by Erhard and depends upon the fact that a normal ear even when tightly closed is capable of hearing a loud-ticking watch at a distance of from 2 to 3 metres.

The patient to be tested is placed in the centre of a large and quiet room and the apparently deaf ear closed with the finger. The watch is now brought to within 6 feet of the patient's good ear and he is requested to count the ticks. The normal ear is now closed and the watch brought to within 1 metre of the other ear, this distance being within the range of audition of the tightly closed normal ear. If now the patient denies that he hears the watch at all, simulation may be diagnosed with certainty.

Careful testing with a large-sized tuning-fork is of value. A C^2 tuning-fork is taken and held alternately at equal distances in front of the two ears. The statement is then made that it is better heard on the sound side. It is then transferred to the median line of the vertex. If the patient has a genuine lesion of the conducting media the sound will be better heard upon the affected or deaf side. The person simulating deafness will, however, hesitate, and say, as a rule, that he hears the sound better in his good ear and probably not at all in the ear which he claims to be the deaf one. If now the good ear be closed and the fork again placed upon the vertex the patient who is really deaf will state either that he hears the sound better upon the closed ear or that he finds no difference between the two ears. The person, however, who feigns unilateral deafness will state at once that he no longer hears any sound, or that if he hears anything it is faint. He also refers it to the ear which he pretends is deaf, and which is open.

McBride lays stress upon watching for involuntary movements of the auricle when listening. These movements, frequently seen during the process of testing, appear to indicate a desire on the part of the patient to hear. Their presence, therefore, would serve to exclude any attempt at malingering.

Stenger's Test.—Two tuning-forks (C^1 or C^2) are taken; each is held 10 cm. from the ears: the sound is heard on both sides; take right away: left only heard, of course; now bring right fork nearer, say 5 cm: patient can now only hear fork on right side.

In malingerer: stand behind and do not let him see the two forks; he would deny hearing by either side; whereas with a diseased right and sound left, the fork would still be heard on the left side.

Treatment.—In the treatment of simulated deafness the suggestion of the use or the actual use of the electric current frequently proves serviceable. In the case of a Methodist parson, who had successfully simulated deafness for five years, and who was surrounded by a group of sympathetic women-folk, the suggestion of the use of powerful electric measures at once restored his hearing.

Such drugs as assafoetida, valerianate of zinc or iron, or bromide of ammonium are occasionally of service. Residence in a high, dry, and bracing atmosphere combined with regular exercise and light nutritious food is also advantageous.

REQUIREMENTS IN REGARD TO THE EAR AND HEARING OF APPLICANTS FOR ENLISTMENT INTO THE ARMY AND NAVY OF GREAT BRITAIN.

ARMY.—Deafness is a cause of rejection if at all marked, *i.e.* if a candidate spoken to in an ordinary tone of voice answers without hesitation nothing more will be required, but if he pokes out his head, puts his hand to his ear, or lets it appear he is deaf, then the examiner will be strict. N.B.—Each candidate has to sign a certificate *on honour* that he is not aware that he is suffering from disease of any kind, so that though he may slip through at first he is liable to be caught if found unfit later.

NAVY.—There must be no impairment of hearing, and there must be no evidence of disease (active or quiescent) of the external, middle, or internal ear. Ear trouble is such a frequent cause of invaliding that the examination is very strict.

CHAPTER XL

DISEASES OF THE NOSE, NASO-PHARYNX, AND PHARYNX SPECIALLY LIABLE TO INVOLVE THE ORGAN OF HEARING.

1. **Acute Catarrhal Rhinitis.**—Acute catarrhal rhinitis or "cold in the head" is a common and, as a rule, simple disease. It may, however, spread backwards to the naso-pharynx and involve the tubo-tympanic mucosa, or downwards to the pharynx, larynx, and lower portions of the respiratory system, inducing symptoms of severity and at times of danger.

Causation.—The main predisposing causes are heredity, tendency to catarrhal affections, adenoids, residence in damp ill-ventilated rooms, certain occupations, age, menstruation, the presence of chronic rhinitis or naso-pharyngitis, and such constitutional dyscrasiae as gout, rheumatism, syphilis, tuberculosis, or alcoholism.

Exciting Causes.—The principal exciting causes may be classified under three headings: (1) exposure to cold, (2) exposure to extremes of heat and cold, (3) exposure to infection.

Exposure to cold draughts, sudden changes of temperature, improper or deficient clothing, and wet feet are potent factors in the production of an acute rhinitis, especially when the powers of resistance have been lowered from one or other cause.

Exposure to heat is also frequently followed by catarrhal attacks. Thus sitting in ill-ventilated lecture rooms, churches, theatres, etc., is followed at times by an acute rhinitis. Prolonged exposure to the sun's rays has also been known to set up an acute catarrh. According to some authorities catarrh so induced is reflex in origin as may be proved by wearing smoked glasses. In winter the variations of temperature to which a patient is exposed are more likely to induce catarrh.

Pathology.—Infective rhinitis or the "common cold" has been bacteriologically studied by many observers in the past few years, yet there seems to be considerable difference of opinion as to the actual causal responsibility of the different micro-organisms found. The difficulties of establishing a specificity are many, for in addition to the fact that not one but several forms are present during an attack, there is also considerable variation in those demonstrated in successive attacks, whether sporadic or epidemic.

By far the commonest organism is the *diplococcus catarrhalis*, which is easily identified as a large Gram – micro-organism, non-capsulated, and growing readily on all media, even on gelatine at 20° C.

Next in frequency is the *bacillus septus* of Cautley, having the appearance of a diplococcus. It will not grow on gelatine, but thrives on serum or agar. It is recognised in thin discharge as a short Gram + diplo-bacillus, about 1·5 mm. in length, often arranged in palisade or cuneiform groups.

The pneumococcus is less common, but is easily identified from its Gram + staining reaction, its capsule, its oval shape, and its growth on blood agar.

Many other bacterial forms, pathogenic and non-pathogenic, are found in the nose and throat during an attack of acute catarrhal rhinitis, but like the foregoing they may also pass a saprophytic existence in those regions. Still their presence in large numbers in the nose and naso-pharynx is only associated with catarrhal symptoms, and their presence must not necessarily be interpreted as affording a causal significance.

The writers have frequently found the *Bacillus capsulatus mucosus* a Gram – thick, stumpy, capsulated bacillus, frequently occurring in chains. It grows best on serum as small discrete "dew-drops." Four bacilli may often be seen in one capsule.

During the fourth or fifth day a profuse flow of brilliant yellow mucus is often seen in the early morning; this may be due to staphylococcal infection, and is indicative of sinusal involvement.

When the pneumococcus is present, almost alone and in large numbers, a middle-ear infection assumes a serious aspect, since this organism is frequently associated with acute osteomyelitis of the mastoid and with meningitis.

Symptoms.—Acute catarrhal rhinitis is ushered in by an intense feeling of irritation in the nasal passages, accompanied by attacks of sneezing, and followed by a sense of dryness and fulness in the nose, frontal headache, and general lassitude. In the course of a day or so there is a profuse, thin, serous discharge which rapidly becomes mucopurulent, tenacious, and difficult to dislodge. On account of the collection of the discharge in the nasal passages and naso-pharynx during the night the patient feels particularly "stuffy" in the morning. His efforts to clear the nose are accompanied by hawking, retching, and in severe cases by sickness. Gradually the fulness and obstruction in the nasal passages begin to pass off, the headache and lassitude disappear, and the nasal mucosa returns to its normal condition.

During the period of severe obstruction the sense of smell may become greatly impaired, and as the result of frequently recurring attacks may disappear altogether.

Complications.—Acute catarrhal rhinitis may be followed by acute catarrhal or purulent inflammation of any or all of the nasal accessory sinuses, naso-pharyngitis, inflammation of the tubo-tympanic mucosa and middle-ear cleft, granulomatous polypi, acute mastoiditis, pharyngitis, laryngitis, bronchitis, or meningitis.

It may also be followed by rarefying osteitis with the ultimate formation of polypi.

Treatment.—To cut short an attack of acute rhinitis the patient should remain at home in bed, and devote himself to treatment.

To produce free diaphoresis a vapour or hot-water bath is advisable. The former is preferable, and in the absence of a proper apparatus may be improvised by placing the patient, wrapped in a blanket, upon a cane-bottom chair, under which a small lamp is kept burning. After free perspiration has been induced the patient should be put into a warm bed, and should drink a tumblerful of hot lemonade, thin gruel, or hot whisky and water. In addition a 10-grain Dover powder may be administered, followed a few hours later by a mild alkaline aperient. The patient should remain in bed for from twenty-four to forty-eight hours, and subsequently one day in the house.

If, on the other hand, the patient is unable to remain at home and in bed, sulphate of quinine (gr. x. per dose) should be given upon an empty stomach in order to try to cut the attack short. Tincture of opium (5 to 10 minims), cinnamon (5-grain tabloids), acetanilide, tartrate of antimony, apomorphine, spirits of camphor, or salicin are also useful.

Local Treatment.—In the early stages of acute rhinitis, benefit at times follows lavage of the inflamed mucosa with warm alkaline antiseptic lotions.

Spraying the nasal passages with a weak solution of menthol in albolene or paroleine, or insufflations of medicated snuffs, bismuth and morphine, iodol and menthol, etc., are useful.

The inhalation of steam, containing various medicaments, *e.g.* benzoin, menthol, camphor, serves to relieve the sensation of dryness and irritation so common in the early stages of the attack, while spraying the nasal passages with cocaine (2 to 4 per cent), to which a few drops of adrenalin chloride solution (1 to 1000) have been added, serves to diminish the swelling and congestion of the turbinal mucosa, and hence to relieve the existing stenosis. Inhalants containing chloretone, adrenalin, anaesthesin, etc., are also useful when applied with a nebulizer after previous cleansing of the nasal passages with an alkaline solution.

When an acute catarrhal attack shows a tendency to become subacute or chronic, a change of air to some dry bracing moorland resort acts very beneficially. During the attack the diet should be light, nutritious, and non-irritating.

In the event of the patient being unable to remain in bed, or even in the house, various methods of relieving symptoms may be adopted. Thus the regular cleansing of the nasal passages with a mild alkaline antiseptic solution, followed by spraying the mucosa with menthol and paroleine, nebulae sedativae (Mottershead), or sterilised vaseline is useful. The frequent inhalation of dry menthol from one or other form of pocket apparatus is a convenient and readily applied form of treatment. Solutions containing cocaine and adrenalin are also very serviceable, but should always be prescribed with great caution. In those cases where the turbinal mucosa becomes thickened as the result of the continuance or constant recurrence of catarrhal attacks, the local application of chromic acid or of the electro-cautery needle by causing cicatricial contraction and pinning down of the redundant mucosa to the underlying bone affords marked and permanent relief.

Preventive Treatment.—Certain individuals, either from an hereditary tendency or from some other cause or causes, are peculiarly liable to catch cold. To prevent this, so far as it is possible, strict attention should be paid to the state of the skin and bowels, to the avoidance of an excessive amount of alcohol or tobacco, to clothing, exercise, and diet. The daily use of the cold bath, when not followed by any want of reaction, and cold sponging of the face and neck, undoubtedly serves to increase the powers of resistance and to promote cutaneous functions. Any tendency to constipation should be combated by the use of an occasional blue or compound aloin pill, followed by a warm alkaline aperient. Alcohol should be very sparingly indulged in, and, except in quite occasional cases, forbidden. Tobacco is undoubtedly best avoided. Woollen or silken underclothing should be worn next the skin, and great attention paid to keeping the feet warm. Wrapping up the throat with furs, scarves, and the like should be avoided, except when driving in an open carriage in cold weather.

Regular exercise should be enjoined, and a complete change of underclothing and a rub down with a rough Turkish towel recommended should free perspiration have resulted.

The diet should be light, nutritious, and easily digested, spices, curries, condiments, etc., being avoided. Great attention should be paid to the value of fresh air as a means of diminishing the tendency to catch cold. Hence rooms should be kept well aired and ventilated, and, as far as possible, at a fairly even temperature of about 60° F.

In infants and very young children acute rhinitis is often a serious disease, from the tendency which it shows to spread to the lungs and to induce capillary bronchitis. The nasal obstruction also prevents the infant from taking the breast, and hence is directly responsible for the production of various digestive troubles. Infection of both ears with consequent acute middle-ear suppuration is also liable to take place. In severe cases the obstruction to respiration may give the impression that the larynx is involved. Recession of the anterior triangle of the neck is indicative of nasal obstruction, whilst sucking in of the chest walls and of the tissues about the supra-sternal notch would indicate laryngeal stenosis.

In the treatment of such cases great attention should be paid to keeping the infant well wrapped up in a warm bed and in a warm, well-ventilated room.

2. **Acute Purulent Rhinitis.**—Acute purulent rhinitis is a fairly frequent disease, especially amongst those living in ill-ventilated, insanitary, and damp houses, and is characterised by an acute inflammation of the nasal mucosa, accompanied by nasal stenosis and a copious purulent discharge. In infants it is undoubtedly induced at times as the result of infection from vaginal discharge and is in many cases of gonococcal origin. It also occurs as the result of measles, scarlet fever, diphtheria, and smallpox.

Symptoms.—Both nasal passages are affected. Hence there is marked difficulty of breathing and in infants inability to take the breast. The onset of the disease is ushered in by a rapid rise of temperature, restlessness, and general malaise. A free discharge of pus soon takes place, followed by irritation or excoriation of the upper lip. In some cases the discharge is foetid. Purulent ophthalmia frequently accompanies purulent rhinitis.

Pathology.—The local changes are at first similar to those of the catarrhal form, but the discharge rapidly alters from a glairy mucous fluid to a creamy or haemorrhagic one. At first a few columnar cells are seen, with small leucocytes of both kinds, their sharply defined outlines being lost, while their cytoplasm becomes granular and their nuclei swollen and fragmented. Lymphocytes are also present, but in relatively small numbers. In addition to the bacteria already referred to in acute catarrhal rhinitis, *streptococci*, *staphylococci*, *bacillus coli communis*, *bacillus proteus vulgaris*, *Pfeiffer's bacillus*, and *bacillus capsulatus mucosus* frequently occur in large numbers, and last, but not least, several of the *diphtheroid* bacilli and the true *Klebs-Loeffler bacillus*, hence a purulent discharge should always be examined.

The gonococcus is by no means rare in both infants and adults.

Diagnosis.—Purulent rhinitis may be mistaken for nasal diphtheria. In the former there is, however, no membrane, whilst in the latter membrane is generally to be found in the nasal passages, or, failing that, in the fauces. A membrane is, however, by no means constant in cases of true diphtheria, the writer having cultivated most virulent specimens of the Klebs-Loeffler bacillus in cases typically purulent and unaccompanied by any clinical evidences of diphtheria. In nasal diphtheria the infant or young person is obviously very ill, the temperature is often not markedly elevated, the cervical glands are enlarged, and the urine contains albumen. There is also marked pallor.

Accessory sinus suppuration at times simulates purulent rhinitis. It is, however, more frequently unilateral than bilateral, the discharge is rarely as free, is intermittent, and a nasal examination will in almost all cases indicate its source.

The suppuration accompanying the presence of a rhinolith or foreign body is also a unilateral discharge, and is generally distinctly foetid.

Prognosis.—The prognosis is good, provided that efficient treatment is carried out. The discharge should be examined with a view to isolate the patient, should it prove to be diphtheritic or gonococcal.

Treatment.—The general health should be maintained by generous diet and the internal administration of such drugs as iron, arsenic, iodide of iron, cod-liver oil, etc.

Locally, great attention should be paid to keeping the nasal passages well cleansed with alkaline antiseptic lotions. All irritating applications should be carefully avoided. Spraying the nasal mucosa after previous irrigation with a 1 per cent solution of menthol in albolene is also serviceable.

3. **Membranous Rhinitis.**—A membranous deposit may occur as a form of rhinitis in children and adolescents which is not specific, *i.e.* not true diphtheria.

It may follow the acute specific fevers, scarlet fever, measles, whooping cough, etc., or may be associated with neglect and insanitary surroundings, being almost entirely confined to the poorest and alien classes.

It is characterised by a plastic exudate simulating true diphtheria, but unassociated with its clinical phenomena.

The exudate consists of a fibrinous network entangling epithelial cells and leucocytes.

Many varieties and large numbers of bacteria are present but no specific organism.

The commonest bacteria found are *bacillus coli communis*, *staphylococcus*, *bacillus pyogenes foetidus*, *bacillus proteus vulgaris*, *bacillus capsulatus mucosus*, *diplococcus catarrhalis*, and the *pneumococcus*.

The discharge eventually becomes purulent, but clears up with local antiseptic treatment and attention to health and hygiene.

4. **Traumatic Membranous Rhinitis.**—This form of rhinitis is generally due to the application of the electro-cautery or the performance of such intra-nasal operations as removal of a septal spur, snaring of polypi, or the amputation of the enlarged ends of turbinated bodies, and is unilateral.

The raw surface becomes covered with a white or yellowish white membranous exudate of firm consistence. If left to itself it gradually separates leaving behind a healthy surface. Constitutional symptoms are rare.

5. **Nasal Diphtheria.**—Nasal diphtheria is characterised by the deposit of membrane in one or both nostrils, and is almost always accompanied by faucial diphtheria. There is a free, purulent, non-foetid, and at times blood-stained discharge. The membranous exudate is of a yellowish colour, is closely adherent to the underlying mucosa, and at times exfoliates in the form of casts of the interior of the nasal chambers. Albuminuria is usual. Constitutional symptoms are at times absent, at other times severe, and the disease, especially in young people, is frequently fatal.

Post-diphtheritic paralysis of the soft palate is by no means an uncommon sequela.

Treatment.—As efficient cleansing of the nasal passages as is possible is imperative.

Anti-diphtheritic serum should be injected as soon as a diagnosis has been made, while tonics and stimulants should be administered.

Should invasion of the middle ear occur with resulting suppuration, free incision of the membrane is necessary to obviate, as far as is possible, extension to the mastoid antrum, the contiguous mastoid cells, and the meninges.

6. **Chronic Catarrhal Rhinitis.**—In the majority of cases chronic catarrhal rhinitis is the result of previous attacks of acute rhinitis. It is possible, and in fact probable, that chronic catarrhal rhinitis is at times chronic *ab initio*, especially amongst those of a gouty or catarrhal diathesis. The various causes already mentioned as predisposing to attacks of acute catarrh are, therefore, also responsible for the incidence of chronic catarrh. Various local factors, such as post-nasal adenoids, septal spurs, and deviations, which give rise to a certain degree of nasal stenosis and consequent impairment of efficient nasal drainage, predispose also to the development and maintenance of chronic catarrhal disease.

Residence in low-lying, damp, ill-ventilated, and badly lighted rooms plays an important part in the aetiology of this condition.

Pathology.—Recent experience has shown that a form of persistent chronic catarrh may exist which is apparently unassociated with any gross lesion excepting that of irritation in the mucous membrane, the vestibule, and adjacent skin. A cultivation from the discharge has yielded pure growths of *staphylococcus* (*albus* and *aureus*) which were obviously responsible for the discharge, being probably lodged and constantly grown in one of the accessory sinuses, although transillumination afforded negative evidence.

Symptoms.—The symptoms the result of chronic catarrhal rhinitis are: (1) nasal stenosis, and (2) nasal discharge.

The degree of nasal stenosis depends upon the region of the nose implicated, the duration of the affection, and the particular type of nasal passage, whether slit-like and narrow, or broad and roomy. The effect produced depends, again, upon the type of hypertrophy which results from the presence of chronic rhinitis, whether a mere turgescence of the mucosa or an actual hypertrophy of its fibrous framework.

The amount of discharge secreted by the inflamed mucosa varies, but is at all times much greater than normal. Although generally fairly fluid and copious in amount, it may tend to become scanty and viscid, inducing a condition of *rhinitis sicca*. In the morning it is generally scanty and difficult to get rid of. As the day advances it tends to become more fluid and watery, variations of temperature and atmospheric conditions being largely responsible for these alterations in its consistence. In addition to the changes, both bodily and mental, produced by chronic nasal stenosis, other complications, such as chronic Eustachian obstruction, chronic otitis media suppurative or non-suppurative, pharyngitis, laryngitis, and bronchitis, are prone to result.

Treatment.—In the treatment of chronic catarrhal rhinitis attention should be paid to the habits, mode of life, and recreations of the patient. As much time as possible should be spent in the open air. Exercises of all sorts, provided that they are not overdone, are beneficial by stimulating the skin and by assisting in inducing nasal breathing. In gouty and full-blooded subjects a regular course of alkaline waters at home or abroad is useful. Attention should also be paid to diet, which should be light and easily assimilated. Alcohol should, as a rule, be stopped, and smoking indulged in only in great moderation. The use of an auto-vaccine made from the patient's discharge affords good results.

Turkish or Russian baths are frequently of considerable service.

In debilitated individuals, tonics, such as iron, arsenic, cod-liver oil, or strychnia, are indicated, as well as a nutritious diet. Such stimulants as Burgundy or port wine may be given with advantage.

Local Treatment.—The local treatment of chronic rhinitis varies with the pathological effect produced by the disease and its situation.

In cases where the mucosa is hypertrophied, and where there is considerable secretion of a thick, muco-purulent, and tenacious discharge, thorough cleansing with some alkaline antiseptic lotion should be practised two or three times daily. For the purpose of irrigation the fluid may be drawn up from the palm of the hand, sprayed into the nasal passages from a coarse nasal spray, or syringed by means of Wingrave's nasal syringe. At least a pint of the prescribed lotion should be used at each sitting, care being taken that no undue pressure is used, otherwise the fluid may be forced up the Eustachian tubes and induce an otitis media. The patient should be instructed to pass the glass end of the Wingrave syringe tipped with a small piece of rubber tubing, along the inferior meatus, and then hold the head over a basin, at the same time protruding the tongue as far as possible. The fluid being now syringed gently along the nasal passage washes out the nose and nasopharynx, and escapes from the opposite nostril. In this way the whole nasal and post-nasal mucosa is cleansed.

When the discharge is particularly tenacious the addition of chloride of sodium or a 2 per cent solution of sodium sulphate is useful.

Following the use of the detergent lotion, pine oil, eucalyptus, menthol, or creasote may be inhaled with advantage. Astringent local applications should be avoided as tending to injure the delicate nasal mucosa.

When irrigation fails to cure the existing stenosis and discharge, resort should be had to cauterisation, which may be carried out by means of the electro-cautery or by the application of some such caustic as chromic or trichloracetic acid.

The nasal passages having first of all been thoroughly cleansed, a 5 per cent solution of cocaine, to which a few drops of (1 to 1000) adrenalin solution have been added, is applied to the engorged and thickened mucosa. After an interval of from five to ten minutes, it is sufficiently anaesthetic to permit of its almost painless application.

Cauterisation may be accomplished in one of two ways, (1) linear, or (2) punctiform, the object being to induce cicatricial contraction and to pin down the redundant mucosa to the underlying turbinated bone.

Linear Cauterisation.—A thin platinum needle is selected and introduced while cold, under efficient illumination, as near to the posterior end of the inferior turbinal as possible. Contact is then made, and the red-hot needle drawn carefully along the whole length of the turbinated body, the greatest care being taken to prevent injury to the septal mucosa, otherwise adhesions between the turbinated body and septum are almost certain to result. Two or three such linear cauterisations may be made, the number varying with the amount of hypertrophy present.

Puncture Cauterisation.—A fine platinum needle is taken and passed when red-hot through the engorged mucosa down to the turbinated bone in from three to four different places at one sitting, and retained in position for a few seconds.

The slough produced as the result of the application of the cautery separates in from eight to ten days, the cicatricial contraction which results materially assisting in the opening up of the previously stenosed nostril.

After cauterisation the nasal passages should be irrigated with a mild alkaline antiseptic lotion.

Sometimes two or three applications of the cautery at intervals of ten days may be necessary to reduce the existing redundancy of tissue. It is advisable to cauterise only one nasal passage at each sitting.

Although the turgescence or hypertrophy is, in the majority of cases, most marked over the inferior turbinated bodies, the mucosa over the middle turbinal, the lower part of the septum, and the floor of the nasal passage may be similarly implicated. Under such circumstances, the application of the cautery point to the redundant portions of mucosa is advantageous and assists recovery. In many cases the posterior end of one or both inferior turbinals is the part principally affected. If, after thorough cocainisation, the turgescence can be seen by means of anterior rhinoscopy, it may be treated by the passage of a fine cautery point through the anterior nares, great care being taken not to wound the anterior lip of the corresponding Eustachian tube.

On the other hand, should it be difficult to define, or should the patient possess a narrow nasal passage, it is better to employ such instruments as the snare or spokeshave for its removal.

Application of Chemical Caustics.—The application of strong chemical caustics, such as chromic or trichloracetic acid, has practically the same effect as the application of the cautery, but is by many considered to produce more reaction and more after-pain. The ease and convenience of their application is, however, an argument in their favour. A preliminary cocainisation of the turgescent mucosa is necessary. A bead of chromic acid is fused on to a suitable nasal probe, or a cotton-tipped probe is dipped in a concentrated solution of the acid, and one or more linear cauterisations made along the whole length of the inferior turbinal, followed by irrigation of the nasal passages with a warm alkaline solution. The slough which forms, separates in from eight to ten days, or may be removed with forceps.

Two or more applications of the drug may be required to produce the necessary amount of cicatricial contraction.

Anterior Turbinectomy.—In certain cases it may be necessary to amputate the anterior end of the middle or inferior turbinal. This may be accomplished (1) by means of a strong pair of nasal scissors, (2) by the combined use of nasal scissors and snare, or (3) by the cold snare alone.

When it is desired to remove only a small portion of the turbinal, a pair of nasal scissors (Fig. 247) is, after a preliminary cocainisation of the mucosa, introduced obliquely into the nasal passage, one blade above and the other below the inferior turbinal, the rounded ends of the scissors pointing towards the septum. The blades are then sharply brought together and the requisite amount of tissue removed.

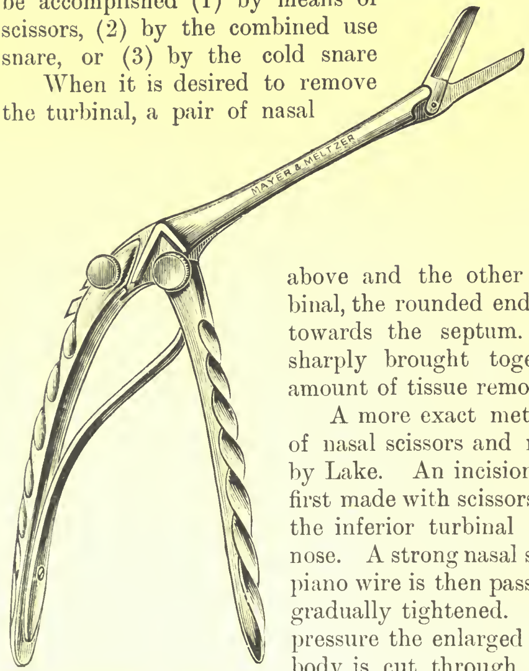

Fig. 247.—Woakes's nasal scissors.

A more exact method is the combined use of nasal scissors and nasal snare as suggested by Lake. An incision of the desired length is first made with scissors along the attachment of the inferior turbinal to the outer wall of the nose. A strong nasal snare threaded with No. 5 piano wire is then passed along the incision and gradually tightened. By slowly increasing the pressure the enlarged portion of the turbinated body is cut through. If done cautiously the amount of haemorrhage is trifling.

Posterior Turbinectomy may be accomplished by means of a wire snare or spokeshave (Fig. 248). Local anaesthesia is frequently sufficient, but in young or nervous patients a general anaesthetic is preferable. The loop of the snare, previously bent, is introduced into the nasal passage and guided along its floor until it reaches the post-nasal space. It is then gently insinuated over the swollen posterior end, and, as soon as it is felt to grasp, the barrel of the snare is pushed backwards to meet the loop, as it were. The redundant portion of the turbinated body is then engaged, and cut through slowly so as to avoid undue haemorrhage. When the patient is under an anaesthetic the engagement of the posterior end of the turbinal in the loop of the snare is much facilitated by the introduction of the finger into the naso-pharynx.

Complete Removal of the Inferior Turbinals.—It may be necessary in certain cases of great enlargement of the inferior turbinals with almost complete nasal obstruction, where cauterisation or a limited turbinectomy has been attempted but without success, to advise its complete removal. The operation should not, however, be undertaken lightly, as the results following complete turbinectomy are at times disastrous, and cause great and permanent inconvenience. Such results are the production of an atrophic naso-pharyngitis, pharyngitis, or laryngitis, with formation of dry foetid crusts.

In suitably selected cases of nasal obstruction the operation has, however, a recognised place. Its performance is also useful in certain cases of hay-fever and constantly recurring vasomotor rhinitis.

Operation.—The patient is placed under an anaesthetic and the head thrown back over the end of the table. An incision is made with a pair of nasal scissors along the anterior attachment of the inferior turbinal to the outer wall of the nose, in order to prevent laceration of the nasal mucosa during its removal. The index finger of the operator's left hand is then passed into the nasopharynx and the spokeshave or Ballenger's large swivel-knife, with its convex surface facing outwards, introduced along the floor of the nasal passage. The enlarged inferior turbinal is then insinuated between the arms of the instrument. By rapidly pulling the handle of the instrument outwards and inclined towards, *i.e.* across the *septum* the attachment of the posterior end only of the inferior turbinal to the lateral nasal wall is severed, the mass coming away with the instrument, or being subsequently picked out of the nasal passage with a pair of forceps. Haemorrhage is at times sharp, but is, as a rule, readily controlled by raising the head or packing the nasal passage with gauze. The gauze tampons should be removed at the end of twenty-four hours and the passage irrigated with a warm calcium chloride alkaline antiseptic lotion.

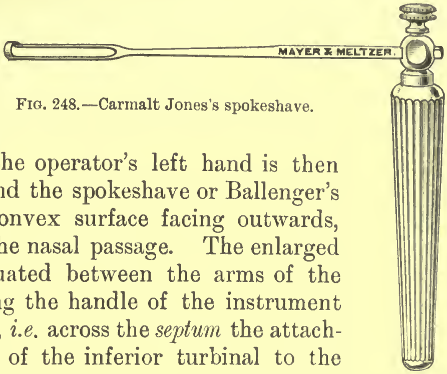

FIG. 248.—Carmalt Jones's spokeshave.

Operations upon the Middle Turbinal.—In certain cases it is necessary to amputate a portion or the whole of the middle turbinated body in order to ensure free drainage of the frontal sinus, fronto-ethmoidal cells, the maxillary antrum, or to obtain access to the anterior wall of the sphenoidal sinus. In other cases chronic hypertrophy or cystic degeneration of the anterior end of the middle turbinal leads to stenosis of the mid-meatal region with consequent interference with the normal inspiratory current and the production of headache and impeded nasal drainage.

Removal of the hypertrophied or degenerated portions may be accomplished by means of nasal scissors or snare, or by one or other variety of punch forceps.

When it is necessary to remove the whole of the middle turbinal its attachment to the main body of the ethmoid should be divided as far backwards as possible with scissors, and a wire loop passed along the incision and over the turbinal itself. When the loop is tightened it severs the remaining attachments (Fig. 249).

7. **Atrophic Rhinitis** (*Ozaena*).—Atrophic rhinitis is characterised by certain degenerative changes in the nasal mucous membrane and turbinated bones, by an undue patency of the nasal passages, and by the presence of a discharge which dries and forms crusts of varying size and shape and of a peculiarly disagreeable odour.

It is a disease which commences in early life, is at times hereditary, and is much more frequently met with in females than in males. It tends, at times, to undergo spontaneous cure between the ages of 40 and 50.

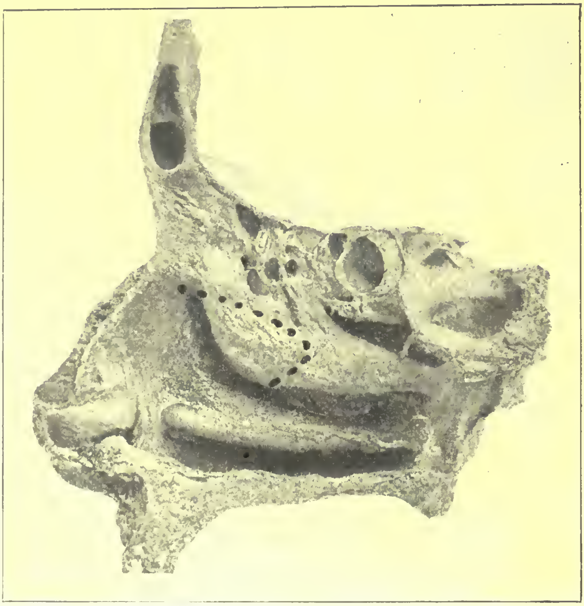

FIG. 249.—Line of incision for the removal of the anterior end of the middle turbinal.

Aetiology.—Despite the numerous investigations relative to the cause or causes of atrophic rhinitis, there is still much diversity of opinion as to what is the exact exciting factor.

The main theories as to its origin are :—

1. That it is the result of purulent rhinitis.

2. That it is a sequel to chronic hypertrophic rhinitis.

3. That it is the outcome of a previously existing rhinitis sicca.

4. That it is due to the presence of purulent disease of one or other of the nasal accessory sinuses.

5. That it is due to a syphilitic or tuberculous taint.

6. That it is due to congenital causes, either non-development of the

inferior turbinals (Zaufal) or absence of ciliated epithelium in the nasal mucosa.

7. That it is due to the presence of a specific micro-organism.

Symptoms.—The subjective symptoms are absence or almost complete absence of the sense of smell, nasal obstruction from the presence of crusts, dry throat, occasional huskiness, and at times a feeling of nausea and depression. The absence of any sense of smell prevents the patient from being conscious of the horrible odour of his breath, a stench which causes him to be avoided by his friends, and which tends to still farther accentuate feelings of depression.

The objective indications of the disease are the presence of large foetid crusts in one or more usually both nasal passages, marked atrophy of the mucosa covering the inferior and, to a lesser degree, the middle turbinated bodies, unduly patent nasal passages, and a dry and glazed appearance of the pharyngeal and naso-pharyngeal mucosa. In early cases the middle turbinal shows no signs of atrophy, and is even occasionally hypertrophied. The bridge of the nose is often flattened.

In well-marked cases the most striking features are complete atrophy of all lymphoid structures, such as the faucial, lingual, and pharyngeal tonsils together with the typical facies due to the infantile shape of nose, viz. the vertical or "tiptilted," nasal apertures, with more or less depression of the bridge.

In females there is usually persistent leucorrhoea.

Involvement of one or both ears may result from septic infection or from a slowly advancing dry catarrhal otitis media. In many cases the larynx becomes secondarily affected, its mucosa presenting a dry and glazed appearance, while crusts, often large and adherent, are found occluding its lumen, and at times inducing attacks of dyspnoea. In exceptional cases the tracheal mucosa is also affected, and presents the same dry atrophied appearance as is seen in the nasal passages.

Pathology.—That the disease is not unconnected with some constitutional taint is supported by the fact that over 60 per cent of the writer's cases afforded a history of tuberculosis. Careful examination of tissue specially removed failed, however, to demonstrate the presence of tubercle bacilli, although many of the histological details closely simulated those of lupoid granuloma. The morbid changes are chiefly confined to the mucous membrane, the bone showing but slight exaggeration in its normal porotic tendency, and consist chiefly of disappearance of lymphoid tissue, obliteration of blood-vessels, atrophy of glands and sclerosis, with hyaline bodies and plasma cells.

Associated with these intranasal degenerative changes was a disappearance of all lymphoid structures, such as the faucial, lingual, and pharyngeal tonsils, giving a smooth, glassy, and roomy appearance to their respective chambers. This phenomenon is so striking as to be pathognomonic in all well-established cases, and serves to differentiate the true atrophic form from rhinitis or pharyngitis sicca.

Some inflammatory hypertrophy may exist in the early stages of the disease, but this is followed by a general atrophy of all structures involving even the larynx, the Eustachian tubes, and the accessory nasal sinuses.

Treatment.—The main essentials are (1) thorough cleansing of the nasal passages, and (2) the adoption of some means to keep up the fluidity of the nasal secretion. In addition to these local measures, attention should be directed to the state of the general health and to the treatment of any complications which may arise.

To efficiently cleanse the nasal passages a good syringe, *e.g.* Wyatt Wingrave's, is necessary. Sprays, however coarse, are never satisfactory, while the use of the nasal douche is fraught with danger to the ears. The particular solution is not of so much importance as the amount used and the method of its employment. Such solutions as physiological salt solution, weak permanganate of potash, collinarium alkalinum, listerine (2 drs. to 1 pint), sanitas (4 drs. to 1 pint), aceto-tartarate of aluminium (50 per cent solution, 1 dr. to 1 pint), bicarbonate of sodium (1 dr. to 1 pint), biborate of soda (1 dr. to 1 pint), and many others are in everyday use, the main requirements being a solution possessing alkaline and solvent properties, while at the same time being not too stimulating. As efficient syringing is of the first importance, and as it will have to be continued for months, if not for years, the patient should be taught exactly what to do. Greasy preparations or ointments are not advised, *i.e.* those of organic nature, owing to their ready decomposition, which increases the foetor. Only mineral fats should be used.

For the first few weeks treatment should, therefore, be done by the surgeon, and all adherent crusts picked away with nasal forceps, an application of hydrogen peroxide being made for softening purposes, if necessary.

Following the detachment of the crusts, the nasal mucosa should be thoroughly rubbed with a cotton-tipped probe in order to produce an artificial congestion and a flow of mucus.

To maintain cleanliness the syringe should be used twice if not three times daily. The regular and daily cleansing of the nasal passages has, if not a curative effect, the effect of removing all crusts, and of preventing the horrible foetor which accompanies their presence and subsequent decomposition.

An exceptionally valuable douche is boiled and filtered tepid sea-water, especially when combined with a sea voyage.

The mucosa being almost anaesthetic a snuff of powdered boric acid with 1 per cent of formalin, which is well tolerated, furnishes an excellent deodorant, antiseptic and stimulant.

To still farther prevent crust formation and to exclude air, the most potent factor in the drying up of the nasal secretion, the passages should be packed with medicated wool or gauze, the latter being preferable. A strip of double cyanide, thymol, or eucalyptus gauze 18 inches long by 1 inch broad is taken and packed into the nasal passages between the septum and the turbinated bodies. It may be placed in position with a pair of angular forceps, or gently pushed in with a blunt crochet needle. At the commencement of the treatment the gauze should be worn day and night, but later, when crust formation has practically ceased, only at night. Should its presence cause irritation and lachrymation, it should be smeared with sterilised vaseline, albolene, or nitrate of mercury ointment. When packing of both nasal passages causes great discomfort, a useful plan is to pack one passage by day and the other by night until tolerance is acquired.

As crust formation ceases, treatment by packing should be gradually discontinued until finally it is stopped altogether.

Daily syringing should, however, be continued for months, while, in order to keep the mucosa moist, spraying the nasal passages with mentholised oil (1 to 20), oil of eucalyptus (1 to 40), or paroleine, is advantageous.

When atrophic rhinitis is associated with, or actually due to, the presence of accessory sinus suppuration, the particular sinus affected should be treated upon the principles described in Chapter XLIV.

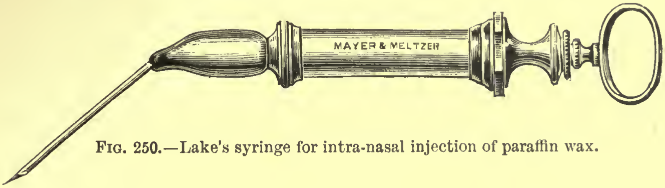

FIG. 250.—Lake's syringe for intra-nasal injection of paraffin wax.

On account of the atrophy of the turbinated bodies, and the consequent too free passage of air through the nasal fossae, Lake and Brindel advocate their being built up by the submucous injection of paraffin wax. Paraffin wax with a melting-point of 105° F. is employed, and is injected with a specially designed syringe (Lake, Fig. 250).

To begin with, from half to a drachm of paraffin wax should be injected first under the mucosa of the posterior end of the inferior turbinal, and a similar amount a few days later under its anterior end. Several injections are necessary to accomplish the desired result. At times slight pain and transient oedema of the tissues of the same side of the face follows, but disappears within a few days.

In several cases in which the writers have employed this method of treatment the results have been satisfactory.

With the idea of stimulating the vasomotor nerves of the turbinal sinuses, Jouslain introduced a method of treatment by cupric electrolysis, and claimed good results. After the application of cocaine, the copper needle attached to the positive pole is thrust under the mucosa of the inferior or middle turbinated body, and the steel needle attached to the negative pole into the septum. A current of from 5 to 10 milliamperes is allowed to pass through for about ten minutes, after which the needles are withdrawn, and the nose lightly packed with gauze. The application should be made once a week.

Such observers as Bayer,[1] Gougenheim,[2] and M'Bride[3] have reported very varying results. Some years ago the writer tried this method in a series of 12 cases of severe and long standing disease, but without lasting benefit.

On the supposition that the disease was due to the presence of an attenuated diphtheria bacillus, Belfanti and Della Vedova[4] recommended the injection of diphtheria anti-toxin. The results obtained have, however, proved disappointing. Massage of the nasal mucosa has been advocated by Freudenthal.

General Treatment.—In most cases general treatment is called for, although in some cases there is no apparent impairment of health. As the disease is especially prone to occur among anaemic or chlorotic patients, tonics containing iron, arsenic, iodide of iron, or phosphorus are beneficial. Cod-liver oil is also useful. Fresh air, warm underclothing, alkaline aperients, and regular exercise should be insisted upon.

In cases of syphilitic origin, mercury and iodide of potassium should be given, or a course of waters at Aix-la-Chapelle recommended. Residence at the seaside is undoubtedly beneficial.

Prognosis.—The prognosis depends largely upon the state of the nasal passages when first seen. In cases where no appreciable atrophy has taken place, and where treatment is conscientiously carried out, the prognosis is good, and a cure may be expected. Where, however, atrophy and structural changes have occurred, no cure, in the strict sense of the word, is possible. Under such circumstances the most that can be done is to arrest crust formation and to ward off complications. As the disease frequently causes great mental depression, patients should be assured that all disagreeable foetor may be entirely kept in check by regular cleansing of the nasal passages.

8. **Rhinitis Sicca Non-Foetida.**—Chronic non-foetid rhinitis occurs amongst two classes of individuals: (1) the plethoric, (2) the anaemic.

It is characterised by the formation of non-foetid crusts and by dryness of the mucous membrane.

The plethoric form of the disease is fairly common among those who follow a sedentary occupation, especially if at the same time they are gouty, dyspeptic, or gourmets. It is also met with amongst those who work in warm and dusty atmospheres. It is more commonly met with in males than in females, and between the ages of thirty and forty-five.

The anaemic form is most common amongst those who are ill-nourished and bloodless, and especially amongst those who work in an ill-ventilated, moist, and dusty atmosphere. It is more common in females than in males, and between the ages of fifteen and thirty.

Symptoms.—In both types of the disease the chief symptoms are a sense of stuffiness and irritation in the nasal passages. In the plethoric type crusts, frequently of large size, form, and by adherence to the septum cause such considerable irritation that the patient is prone to pick them off with his finger-nail with resulting laceration and ulceration of the mucosa, followed by perforation of the septal cartilage.

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[1] Beyer, *Revue hebdom. de laryngol.*, May 1896.

[2] Gougenheim, *Annal. des maladies de l'oreille*, Nov. 1898.

[3] M'Bride, *Ed. Med. Journal*, March 1899.

[4] *Revue hebd. de laryngol.*, May 2, 1896.

In the anaemic type perforation is even more prone to occur on account of the great want of nutrition and of tendency to repair.

Such perforations occur just within the vestibule, and present clean cut and perfectly healed edges. In both types pharyngitis sicca and laryngitis sicca are prone to appear.

Many patients complain of actual nasal obstruction even in abnormally "roomy" nostrils. This is due to dryness of the mucosa causing anaesthesia, so that the air current through the nostrils is not felt, hence causing the sensation of stuffiness.

Treatment.—In the plethoric form of the disease regular exercise and frequent hot-water baths are called for with, in addition, a course of some alkaline water, *e.g.* Apenta, Friedrichshall. Gouty or dyspeptic symptoms should be treated upon general principles, while alcohol and tobacco are best withheld for the time being.

In the anaemic form, tonics, such as iron or arsenic, and outdoor exercise, are necessary.

In aggravated cases it may be incumbent to advise a change of occupation.

A course of alkaline aperients is also advisable.

Locally, the main indication is to remove crusts, and to stimulate the glandular elements of the nasal mucosa. Alkaline washes should be used with the syringe two or three times daily, and adherent crusts removed with forceps or by the local application of peroxide of hydrogen.

Subsequently, spraying with oily solutions of menthol, eucalyptus, or pine oil is advantageous.

9. Rhinitis Caseosa.—Rhinitis caseosa is a disease rarely met with. It is characterised by the formation of cheesy or putty-like masses within the nasal passages, marked nasal obstruction, and a disagreeable odour from the breath. On account of the olfactory region being implicated the foetid odour is not, as a rule, perceived by the patient himself, but is very evident to those around.

The actual cause of the disease is unknown. It has been ascribed to syphilis, tubercle, influenza, accessory sinus disease, and chronic catarrhal rhinitis with retention of secretion.

Pathology.—Caseous rhinitis is nearly always associated with sinusal trouble, since on removal of the putty-like matter one or more of the accessory sinuses are found to be involved, and exhibit free communication with the nasal cavities. The caseous accumulation is often considerable in amount, has an intensely foetid odour, and looks like and has about the same consistency as German yeast. Microscopically, it consists of an amorphous granular matrix containing a great variety of micro-organisms. Laminated epithelial cells may often be seen on the caseous matter nearest to the mucous lining, but the bulk of the material is caseated, and consists of fatty degeneration products following accumulation of leucocytes, and epithelium digested by cytases. The micro-organisms observed by the writer, in a large number of cases, were various *mycelia*, *yeasts*, *leptothrix*, *cladothrix*, *spirochaeta foetida*, *bacillus fusiformis*, *bacillus subtilis*, and *bacillus coli communis*. Osseous lesions are occasional, but not essential companions to caseous rhinitis.

Symptoms.—The prominent symptoms are nasal obstruction, anosmia, and the discharge of an extremely foetid, thick, inspissated, and putty-like material.

Frontal headache is, as a rule, complained of, and more or less anosmia prevails.

Treatment.—In comparatively mild cases the nasal passages may be cleared of all inspissated secretion under local anaesthesia, but in the more severe a general anaesthetic is necessary.

Success in treatment depends almost entirely upon the thoroughness with which the putty-like masses are removed. In certain cases it may be necessary to open up the maxillary antrum or to ablate the ethmoidal cells in order to get rid of all accumulation.

Subsequently the nasal passages should be well irrigated with a mild alkaline antiseptic solution, and sprayed with mentholised paroleine.

10. **Intranasal Obstructions.**—Obstruction to nasal breathing may be temporary or persistent.

Temporary obstruction may be due to acute swelling such as occurs in connection with an ordinary cold or from exudation products, especially of the dense mucous or membranous type. It further occurs in all cases when there is a disproportion between the size of the cavity and its chief contents, the turbinal bodies, which is specially marked in infancy before the first dentition, and in childhood before the second dentition which coincides with the full development of the maxillary sinuses.

Further temporary obstruction may be caused by functional conditions, as, for instance, the sudden enlargement of the erectile tissue of the inferior turbinals at the period of puberty in both sexes, and its coincidence with menstruation and pregnancy in females. A marked hypertrophy of this structure has also been observed at the menopause.

It need scarcely be emphasised that such swellings should on no account be dealt with surgically, although the use of mild local applications, such as an occasional alkaline douche, oily sprays of menthol or weak menthol ointment, with or without adrenalin, are useful. The full development of the maxillae in such conditions will be associated with the restoration of complete nasal breathing in the absence of any permanent deformity.

Persistent obstruction may be caused by deformities of the skeletal walls of the nose, by permanent forms of hypertrophy of the mucous membrane, by collapse of the alae nasi, or by new growths.

Alar Collapse may be structural or paretic. In the former, there is considerable thinning of the external cartilages, so that they are not sufficiently curved or resilient to maintain complete patency of the anterior nares. This, combined with intranasal insufficiency and prolonged abeyance of the habit of breathing through the nose, results in such a state of "flabbiness" that on the slightest sudden negative or inspiratory pressure the anterior apertures become completely closed. There is not only attenuation of the cartilages themselves, but the dilating muscles from non-use undergo atrophy or are never fully developed.

Paresis is generally unilateral, and may follow injury, diphtheria, mumps, and any form of facial palsy.

Treatment.—In addition to correcting intranasal pathological conditions, attempts should be made to restore function by education in proper nasal breathing and by voluntary dilatation of the nostrils. This can be assisted by massage of the alae, by the use of the continuous and interrupted current, supplemented by the intermittent (not constant) wearing of short lengths of soft rubber tubing in the vestibule. When these are in position, gently repeated digital massage will help the restoration of function in the atonic muscles. Special rings and wire dilators are not to be recommended.

11. **Permanent Hypertrophies of the Mucous Membrane** are usually referred to in connection with the subject of hypertrophic rhinitis, but there are other forms which demand special consideration.

The nasal cavities contain normally two varieties of tissue which possess important functions, but are subject to such marked hypertrophy as to cause serious obstruction.

The first is *lymphoid* tissue. This is found chiefly in connection with the middle or ethmo-turbinal region, and in various situations on the septum, but its distribution is very irregular. It may not only be the seat of simple hyperplastic change, but is also particularly liable to bacterial and toxic infection as in tubercle, lupus, glanders, streptothrix, etc.

The second type of tissue is the *vascular or erectile*, consisting of enormous venous channels, surrounded by muscular and elastic walls, which undergoing atrophy lead to permanent distension.

This tissue is distributed most regularly and symmetrically. It is chiefly confined to the posterior end of the inferior or maxillo-turbinal body, extending along its lower or free border as far as its middle. This is easily seen as a corrugated or brain-like appearance of the region, in striking contrast to the smoother anterior end, where glands replace the erectile or cavernous structures.

While this cavernous tissue is subject to periodical and functional congestion, its permanent engorgement may easily be recognised by anterior or posterior rhinoscopy. That its enlargement is permanent is readily shown by the fact that it does not contract under cocaine or adrenalin owing to atrophy of the visceral muscle fibre. The posterior end may be easily felt by palpation, or seen by the mirror as a red or purple mulberry-like swelling.[1]

12. **New Growths.**—(1) Simple mucous polypus may be either a localised hypertrophy of the mucous membrane or a true hyperplasia of all or

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[1] Turbinal Varix, *Lancet*, 1895.

portions of the tissue elements, *e.g.* there is the cystic form chiefly characterised by distended gland ducts, the vascular or capillary type in which blood and lymph capillaries are numerous and dilated, the myxoedematous or seroedematous type characterised by degeneration of the connective tissue cells whose mucigen is converted into mucin by absorption of water, or the connective tissues spaces distended by serum, the dropsical type.

(2) Next to polypi the most frequent type of intranasal growth is the *granuloma.*

Many of the so-called polypi, however, originate in granulomatous tissue which has undergone myxoedematous or seroedematous degeneration and, owing to their pendulous character and exposure to moisture, have assumed a polypoid form.

The different types of granuloma have been described in detail under aural pathology (p. 272). It need only be emphasised that their persistence in this situation is at all times strongly presumptive of an osseous or sinusal lesion.

Of the non-specific types a not uncommon infection is the streptothricial, a form almost invariably associated with sinusal disease and occurring also in the lungs and lymphatic glands.

Without entering minutely into the subject of nasal neoplasms, it will be seen from the appended list that although no type of tumour occurs in this region which is not to be found in other parts of the body, there are some which are rarely seen here, and some which are strikingly common, conditions almost justifying the view that the nasal cavities possess a special pathological anatomy of their own. The writers have never at any time seen a genuine schirrus or colloid cancer, but a type of columnar epithelioma is very characteristic of the region. Further, endotheliomata, the columnar form of papilloma, and varieties of angioma are peculiarly common.

That the tumours of this region possess an interest of their own is shown from the following list of 140 specimens examined for diagnostic purposes :—

Malignant Growths

Epitheliomata—	Squamous	3	
	Alveolar	5	
	Columnar	2	
		—	10
Mesotheliomata—	Endothelioma	7	
	Perithelioma	2	
		—	9
Sarcomata—	Round cell	12	
	Spindle cell	6	
	Myeloid	2	
	Angio-sarcoma	7	
	Myxo-sarcoma	1	
	Osteo-sarcoma	1	
		—	29

INNOCENT GROWTHS

Fibromata	Myxo-fibroma	19	
	Angio-fibroma	11	
	Chondro-fibroma	1	
		—	31
Papillomata	Squamous	4	
	Columnar	12	
	Angiomatous	3	
		—	19
Granulomata	Non-specific	22	
	Syphilis	11	
	Tubercle	6	
	Lupus	3	
		—	42
	Total		140

Special care should be taken in carefully examining all portions of the tumour, since in several cases only a small area exhibited malignant evidence, the greater part presenting the features of simple myxoedematous tissue.

Arising in the accessory cavities there is a type of columnar epithelioma frequently found. It strikingly resembles the malignant adenoma of the intestinal tract.

The mesothelial type is by no means uncommon in the nose. By reason of its being so sharply circumscribed in its early stages it may be viewed as possessing a lower degree of malignancy than the other sarcomata. Although belonging properly to this group, mesotheliomata are grouped separately.

Angiomatous tumours are very common, and when found on the septum and floor are described as "bleeding tumours." Owing to their great vascularity frequent, sudden, and serious attacks of epistaxis are common.

Papillomata.—Papillomata are of two distinct kinds, determined by their site.

The ordinary squamous or warty form occurs, as a rule, in the vestibule, the region of stratified or cutaneous epithelium. But they are sometimes seen on the mucosa of the septum, the covering epithelium having undergone metaplasia. This form is generally small in size, and is of the angiomatous or bleeding type.

The columnar form, which always occurs on the mucous membrane, is larger, softer, and moriform in appearance. It may involve the floor, the septum, or the anterior end of the inferior turbinal. Microscopically it consists of a fimbriated core of vascular myxoedematous tissue covered with columnar or palisade epithelium, ciliated or plain. It may attain such a size as to cause complete unilateral nasal obstruction, and even to depend from the anterior naris, or may be so small as to give rise to no symptoms. It may be sessile or pedunculated.

Treatment.—If springing from the cutaneous lining of the vestibule, papillomata may readily be snipped off with scissors or the cold snare.

If situated farther inwards they are best removed with a cold wire snare. After removal the haemorrhage should be arrested by pressure, and the point of origin cauterised with concentrated chromic acid. In exceptional cases it is at times advisable to cut away a portion of the skin or mucous membrane around the point of origin of the growth.

Small sessile papillomata may also be readily destroyed by the application of the cautery.

Fibromata.—Pure fibromata springing from the periosteum of the bony framework of the nose or from the septum are somewhat rare, but attain considerable size in the nasopharynx. When very vascular, spontaneous haemorrhage constitutes their chief danger.

They present as hard, dense, smooth, or lobulated growths of a reddish colour, and attain at times such a size as to cause marked external deformity.

Symptoms.—If small they give rise to little else than a varying degree of nasal obstruction. If large they are prone to encroach upon the olfactory region with resulting parosmia or anosmia, or to extend backwards to the nasopharynx, causing difficulties in both respiration and deglutition. Other common symptoms are frontal headache, deafness, and spontaneous attacks of haemorrhage. Should the growth become ulcerated, attacks of haemorrhage are both frequent and severe. The interference with nasal drainage which their presence causes leads to a constant muco-purulent discharge which is at times extremely foetid. Gradual increase in size leads to external deformity and encroachment upon vital structures.

Treatment.—Should the growth be small and accessible it may be removed by means of the cold wire or cautery snare. As it is in most cases tough and hard, strong steel wire (piano No. 5) should be chosen, and the loop made to encircle the pedicle as near to its base as possible. By slowly tightening the pedicle is first strangulated and then gradually cut through. Haemorrhage is invariably severe, and should be checked by pressure, the local application of adrenalin chloride, searing the cut surface with the galvano-cautery, or by syringing the nasal passages with very warm sterilised water. On account of the tendency to haemorrhage it is a useful plan to prescribe two or three drachms of a solution of calcium chloride or lactate of calcium for three or four days before operation.

In very large and inaccessible growths an external operation should be performed.

However thoroughly the operation is done, recurrence is prone to take place.

Angiomata (*bleeding polypus of the septum*).—Angio-fibromata and angio-papillomata grow occasionally from the mucous membrane covering the cartilaginous septum and from the floor of the nose. They vary in size from that of a small pea to that of a full-sized bean. They are extremely vascular, and give rise to repeated attacks of severe and spontaneous haemorrhage. Unless thoroughly removed they are prone to recur.

They present as red vascular tumours, and if large cause a certain amount of nasal obstruction.

Treatment.—They may be removed by means of a cold wire snare. The point of attachment after haemorrhage has been checked should be thoroughly cauterised with concentrated chromic acid or the electro-cautery, its application being repeated three or four times at intervals of three or four days. In case of recurrence they should be removed by dissection. An incision down to the cartilage is made with a knife or a fine cautery point around and at a distance of about quarter of an inch from the point of attachment of the growth. The muco-perichondrium is then dissected up with forceps and elevator and removed with the growth attached to it.

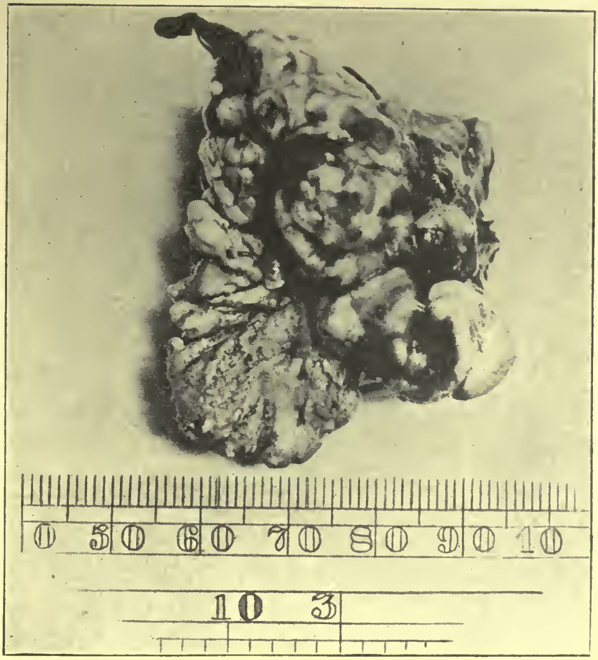

FIG. 251.—Large exostosis springing from roof of maxillary antrum and presenting in nasal passage.

To promote healing the nasal passages should be kept well cleansed with an alkaline antiseptic lotion, and to prevent the formation of crusts sprayed with albolene or paroleine.

Enchondromata.—Enchondromata are rare nasal growths, and spring either from the cartilage of the septum or from the roof of the nasal passage, or more frequently from the maxillary sinus.

They present as hard, smooth, slowly growing tumours with little tendency to spontaneous haemorrhage.

Their gradual increase in size gives rise to nasal obstruction, and ultimately to deformity.

Treatment.—In favourable cases it may be possible to remove an enchondroma through the nasal passage. As a rule, however, an external operation is required, the particular type of operation depending upon the size and situation of the growth.

Osteomata.—True bony growths arising in the nasal passages are rare. They are occasionally met with, however, springing from the bony walls of the accessory sinuses. In a case seen by the writer the growth sprang from the orbital plate of the right maxillary antrum, caused an upward and outward displacement of the corresponding eyeball, and unilateral nasal obstruction. The mucous membrane covering the portion of the growth presenting in the right nasal passage was polypoid, and at first sight gave the impression of an ordinary nasal polypus. The growth was removed by external operation, and presented the appearances shown in Fig. 251.

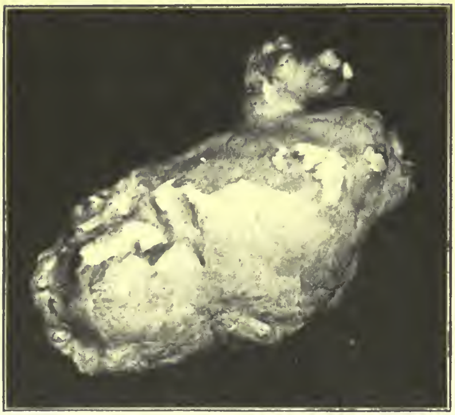

FIG. 252.—Exostosis springing from left frontal sinus and causing great displacement of eyeball.

In another case the growth sprang from the wall of the left frontal sinus, and caused an outward displacement of the eyeball and much external deformity. It was successfully removed by external operation (Fig. 252).

The particular method of removal must of necessity be regulated by the size, position, and origin of the growth.

Prognosis is good, recurrence rarely taking place.

13. **Septal Spurs.**—A septal spur is a localised thickening of the cartilaginous or bony septum, or of both combined. Occasionally it is soft, and consists simply of hypertrophied mucosa resembling a normal structure which is found in many of the lower vertebrates, the so-called "tubercle" of the septum. It is frequently associated with a deflection of the septum. The size of the spur and the amount of obstruction produced vary within wide limits. At times the obstruction caused is of no pathological significance; at other times it interferes with respiration, with nasal drainage, and with the passage of instruments, *e.g.* the

Eustachian catheter. A frequent site of localised thickening is along the ethmo-vomerine crest or suture.

Treatment.—Septal spurs may be operated upon under local or general anaesthesia, and by means of knife, saw, or spokeshave. When a large spur has to be removed it is advisable to preserve the mucous membrane, otherwise a raw surface is produced, upon which troublesome scabbing takes place. After having anaesthetised the mucosa with cocaine-adrenalin solution, an incision is made along the convex surface of the spur, and the muco-perichondrium raised in an upward and downward direction with a suitable elevator from the underlying cartilage. A blunt-pointed and slightly concave knife is then introduced under the spur and the desired amount of cartilage cut away. The muco-perichondrial flaps are then replaced and the nasal passages lightly packed with gauze.

Instead of a knife a nasal saw (Fig. 253) or spokeshave may be used, the former being more serviceable when the spur is bony, the latter when it is cartilaginous.

In the case of a smaller spur or a bilaminar septum, or when the patient is highly nervous, the mucosa may be sacrificed. Healing is, under such circumstances, more prolonged, and local treatment in the form of an oily spray or an alkaline lotion is required to check the tendency to the formation of crusts.

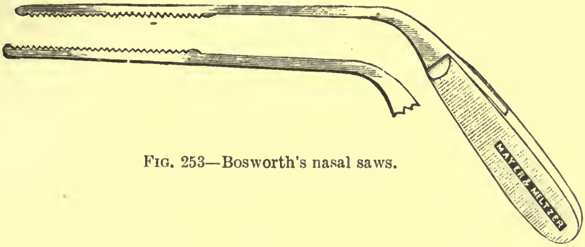

Fig. 253—Bosworth's nasal saws.

It may here be remarked that the vomerine area of the septum is usually bilaminar, therefore removal of a spur in this situation is less likely to cause perforation than in the ethmoid area, which is a single and thinner layer of bone.

14. **Intranasal Adhesions.**—Adhesions may take place between the mucosa of the septum and that covering the outer wall of the nose. The most frequent situations are between the septum and the inferior or middle turbinals, and between the two turbinals themselves.

They may be long and thin or of the nature of a web, and are the result of ulceration, tuberculous, syphilitic, or diphtheritic, too energetic cauterisation, trauma, or the presence of foreign bodies.

Congenital webs are at times found in the anterior nares at the junction of the mucosa with the dermis of the vestibule, or as the result of syphilitic ulceration.

Complete occlusion is seen in rhinoscleroma and the rhinosclerosis of syphilis.

Symptoms.—At times intranasal adhesions give rise to no special symptoms. In other cases they may cause a varying degree of nasal stenosis and chronic rhinitis.

Treatment.—When no symptoms are produced no treatment is necessary. When, on the other hand, their presence gives rise to difficulty in the examination of the nose or the passage of the Eustachian catheter, or when, from their size and position, they interfere with respiration, they should be removed. Removal may be effected with cutting instruments, *e.g.* Mayor's knife, or by division with the cautery.

After division, the ragged edges should be clipped away with a suitable pair of nasal scissors, and a rubber finger-stall lightly packed with gauze or a thin celluloid splint introduced between the raw surfaces so as to prevent re-adhesion.

Adhesions frequently co-exist with spurs upon the septum or in cases where the septum is markedly deflected.

In the former instance the spur should be first sawn off and the adhesion subsequently divided with scissors; in the latter the adhesions should first of all be severed and the deflection rectified afterwards.

15. **Dislocation of the Triangular Cartilage.**—This is, as a rule, caused by some form of traumatism, and leads at times to marked nasal stenosis with all its attendant discomforts. The deformity is usually quite visible, or may be made so by simply tilting up the point of the nose.

In such cases a varying degree of chronic rhinitis is generally present, with, in addition, a certain amount of hypertrophy (compensatory) of the inferior or middle turbinal upon the concave side.

Treatment.—Under local anaesthesia a curved incision is made over the most projecting portion of the cartilage, and the muco-perichondrium raised in the form of a flap. The cartilage is then carefully cut through and separated from the muco-perichondrium of the opposite side. An amount of cartilage necessary to ensure complete patency of the nasal passage is then removed with knife or scissors.

16. **Deviations of the Septum.**—Deviations of the skeletal elements of the septum may, for practical purposes, be divided into two kinds, viz.: (1) those involving deviation in the vertical axis like the movements of a screen or door, and (2) those involving the horizontal axis or crumpling up like a concertina.

While the first or vertical may be due to traumatism, the second or horizontal are chiefly developmental. Perhaps no subject has ever received more speculative attention by rhinologists than this has done during the past twenty-five years. It will be, therefore, expedient to restrict its discussion to a purely practical aspect. The nasal septum of the adult consists of three distinct portions—an upper or ethmoidal, a lower or vomerine, and an anterior or cartilaginous (*v.* Fig. 255). Between the upper and the lower passing in an upward and backward direction is the ethmo-vomerine suture, which sometimes remains cartilaginous and may be the site of a "spur." During early life the whole septum is cartilaginous, and covered with muco-perichondrium. The lower or vomerine element is ossified in *two layers on* the intervening cartilages which is ultimately absorbed. It is, therefore, a bilaminar structure sometimes showing a large intervening cavity, and any projection may involve *one* side only. But the upper or ethmoidal segment is formed from a single centre *in* the cartilage, and is, therefore, composed of a *single* plate, and any deviation or crumpling will necessarily involve *both* nostrils.

Thus a knowledge of the general principles of the septal structure will greatly facilitate the correction of its deformities.

Treatment. — Previous to operation upon the nasal passages, the vestibule, which is the principal habitat of organisms, should be disinfected.

Before operating upon any case of deviation of the nasal septum it is necessary to carefully examine the condition of the interior of the nose, as rectification of the deflection may fail to relieve stenosis, on account of the septum, when straightened, coming into contact with a hypertrophied middle or inferior turbinated body in the previously roomy side. It is therefore necessary to reduce the size of the hypertrophied turbinal by linear or punctiform cauterisation, or by removal of its anterior or posterior ends.

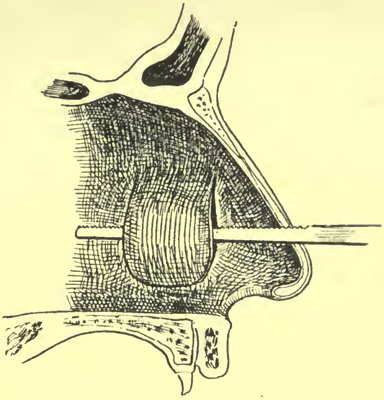

FIG. 254.—Gleason's operation.

Various operative procedures have from time to time been suggested for the purpose of rectifying deflected septa. The type of deflection, the amount of obstruction produced, and the capacity of the nasal passages should be considered in determining which operation to perform.

Gleason's Operation is suitable in cases of simple deflection of the cartilage, and may be performed under local or general anaesthesia.

A knife or nasal saw is introduced under the deflection to cut upwards by regular to-and-fro movements until the deflection is cut through, except at its upper attachment. In this way a somewhat U-shaped flap is produced (Fig. 254).

The operator's finger is then introduced into the obstructed nostril and the flap forcibly pushed through the button-hole in the septum until it overrides the edges of the U-shaped incision. The flap being somewhat larger, on account of its bevelled edges, than the button-hole through which it has been pushed, is thus prevented from slipping back.

To still further reduce resiliency, the U-shaped flap should be fractured at its base by forcible bending.

Both nasal passages should then be packed with gauze, which should remain *in situ* for at least forty-eight hours, after which it should be removed and fresh packing introduced after cleansing the passages with an alkaline antiseptic lotion.

Packing should be retained in one or both nostrils until complete healing has taken place.

The results of this operation, which may be quickly and easily performed, are excellent.

The Submucous Resection Operation.—The advantages of the submucous operations designed by Killian and Freer are that the deflected portions of cartilage and bone are removed without any sacrifice of mucous membrane, that comparatively little after-treatment is necessary, and that no nasal splints have to be worn. The disadvantages are that the operation is often difficult to perform, and consumes a considerable amount of time. The excellent results and the great relief given compensate, however, for the time spent upon its performance.

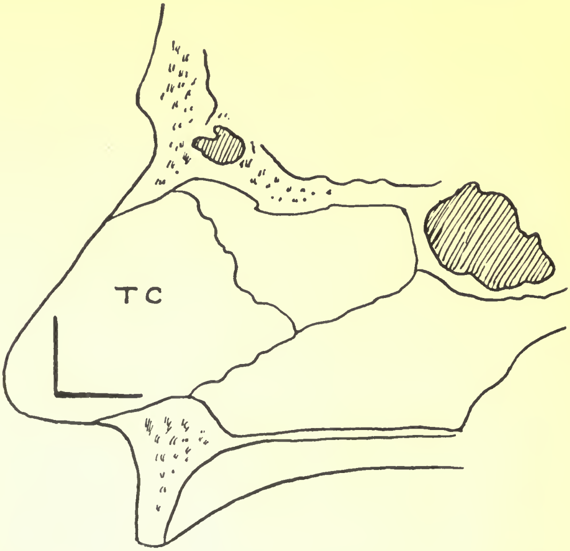

FIG. 255.—Lines of incision for submucous resection of nasal septum. TC, Triangular cartilage.

Killian's Operation.—The operation may be performed under local or general anaesthesia. The former is, as a rule, sufficient when the deflection is mainly confined to the cartilaginous portion of the septum, the latter when both bone and cartilage are implicated. For a few days previous to operation 2 to 3 drachm doses of the elixir of lactate of calcium should be given. This drug has the property of increasing the coagulability of the blood and hence of diminishing the tendency to haemorrhage, always a serious hindrance to rapid work. In addition, both nasal passages after being cleansed should be packed for 10 to 15 minutes previous to operation with a strip of gauze soaked in cocaine-adrenalin solution. If the operation is to be performed under local anaesthesia an injection of the same solution should be made under the mucosa upon both sides of the septum. The patient should be seated upon a straight-backed chair and the head held by an assistant. Should, however, the operation be performed under general anaesthesia, the patient should lie upon the table with his head and shoulders slightly raised upon a firm and hard pillow.

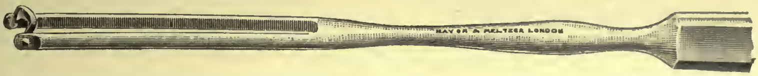

Fig. 256.—Ballenger's swivel knife.

The post-nasal space having been plugged with a sponge, an incision of an L-shape (Fig. 255), or a crescentic incision with its convexity facing forwards, should be made through the muco-perichondrium on the convex side and a flap raised with a suitably shaped elevator. Should the deflection, however, be situated far back, an incision upon the concave side is at times preferable. The muco-perichondrium should now be separated from the underlying cartilage upwards, backwards, and downwards, and well beyond the limits of the deflection. For this purpose an angular elevator is particularly useful. The cartilage should then be incised and carefully separated from the muco-perichondrium upon the concave side, great care being taken to avoid button-holing it. The separation of the cartilage from the muco-perichondrium of the concave side should be carried out in the same way and for the same distance as upon the convex side. The cartilaginous and bony portions of the deflected septum now stand out prominently and quite clear of the soft tissues upon either side. The deflected cartilage is then removed with a swivel knife (Fig. 256) (Ballenger) or with forceps (Jansen, Foster-Ballenger), and the deflected portion of the bony septum with forceps, gouge, or chisel. This manipulation is much facilitated by placing a blade of Thomson's modification of Thudichum's speculum upon either side of the denuded cartilage, and working between its opened out blades.

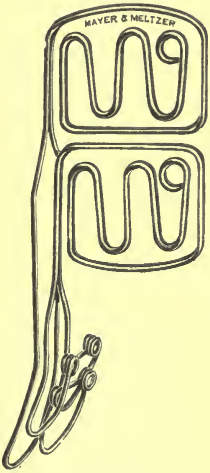

Fig. 257.—Brüning's septum splint.

Considerable difficulty is at times encountered in removing the *crista maxillaris.* No twisting or tearing away of cartilage or bone should ever be attempted, otherwise the muco-perichondrium is almost certain to be lacerated. The two sheets of muco-perichondrium are now allowed to fall together and are kept in position by packing the nasal passages with gauze or by the introduction of Brüning's splints (Fig. 257). The writer introduces into each nasal passage a sterilised rubber finger-stall, lightly packed with gauze and smeared with sterilised vaseline. This splint is non-adherent, is very easily removed, and creates no discomfort. If necessary a horse-hair stitch may be introduced to keep the edges of the original incision in apposition. The rubber splints are removed at the end of forty-eight hours, or sooner if possible, by which time the two layers of muco-perichondrium will have become adherent. Splints made of celloidin are also serviceable.

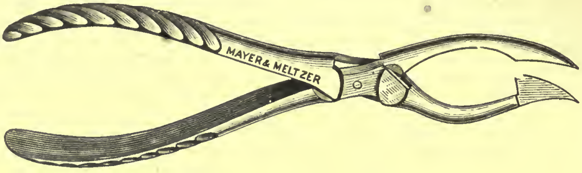

Fig. 258.—Asch's scissors.

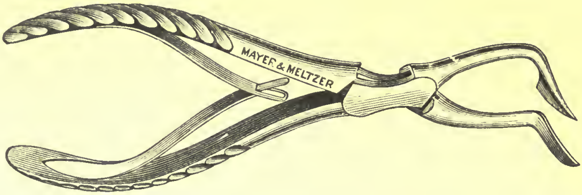

Fig. 259.—Asch's curved scissors.

The nasal passages are subsequently irrigated with a warm alkaline antiseptic solution and sprayed with mentholised vaseline.

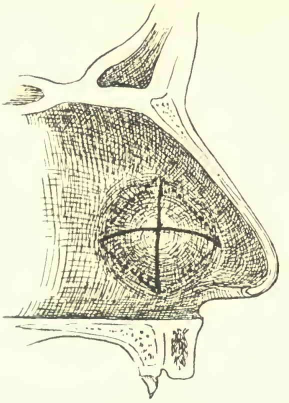

Fig. 260. — Asch's operation. The dark lines indicate the lines of incision through the deflected portion of the cartilage.

Asch's Operation.—Asch's operation is useful when the deflection is confined to the cartilaginous portion of the septum and when rapidity of operation is an object. It is not now performed so frequently, the submucous operation having largely superseded it.

Cocaine-adrenalin solution is first freely applied to the septal mucosa. A horizontal incision is made with a special pair of scissors (Fig. 258) through the whole thickness of the septum at the point of greatest convexity. A vertical incision is also made through the whole thickness of the septum across the centre of the first incision. In this way four triangles are formed with their apices meeting (Fig. 260). Pressure is then exerted with the operator's index finger upon the convex side of the septum until the four triangles are forced across the middle line and into the concave side. To ensure success and to prevent recoil, the pressure exerted should be sufficient to fracture the cartilaginous triangles at their bases. The edges of the triangle will now be found to override, and should be kept in position by the introduction of Asch's special hollow aluminium or celluloid splints. These splints should be worn for from three to four weeks until complete union of the over-riding edges has taken place, the nasal passages being meanwhile irrigated once or twice daily with a warm alkaline antiseptic solution.

Krieg-Bonninghau's Operation.—This operation frequently spoken of as the "fenster-resection" operation is useful in certain cases, but has the great disadvantage of leaving for many weeks a large raw surface denuded of epithelium upon which hard crusts form with resulting discomfort.

After the free application of cocaine-adrenalin solution or under general anaesthesia an L-incision is made, the vertical limb well in front of the convexity and the horizontal limb well below it. The incisions are carefully deepened through the cartilage, great care being taken not to perforate the muco-perichondrium of the opposite side. The muco-perichondrium upon the concave side is then separated from the cartilage and bone as far backwards as is deemed necessary. The whole of the convex portion of the septum with mucous membrane attached is now completely sawn off or removed piece-meal with cutting forceps.

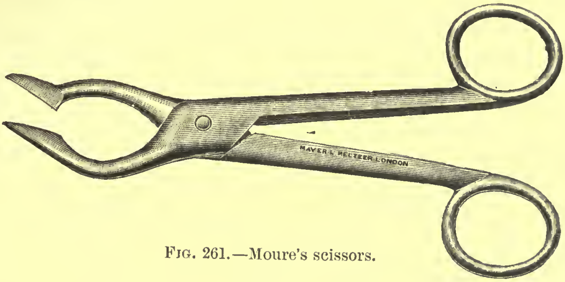

FIG. 261.—Moure's scissors.

The septum is then formed solely by the muco-perichondrium lining what was originally its concave side.

A period of from six to eight weeks elapses as a rule before the raw surface already spoken of is covered with epithelium, and during this time, in order to, as far as possible, prevent the formation of crusts, the nasal passages should be thoroughly cleansed with an alkaline antiseptic solution and subsequently sprayed with menthol-paroleine.

Moure's Operation.—An incision is made with a special pair of scissors (Fig. 261) through the whole thickness of the septum parallel to the floor of the nose, and below the deflection, extending from as far backwards as is deemed necessary to within half an inch or thereby of the tip of the nose. A second incision also through the whole thickness of the septum is then made parallel to the bridge of the nose. The two ncisions should not, however, meet, an interval of at least half an inch separating their anterior extremities (Fig. 262).

The convex portion of the septum is then forced across the middle line into the originally concave side by special forceps, and is kept in position by the introduction of a special malleable splint (Fig. 263). The splint should be worn for from seven to ten days, by which time union of the overriding edges has taken place.

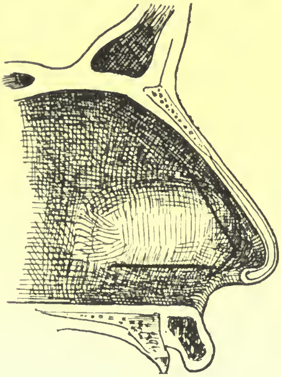

FIG. 262.—Moure's operation. The dark lines indicate the incisions through the deflected cartilage.

Previous to the performance of this operation any septal spur which may exist should be removed with a spokeshave. It is at times advisable as a preliminary step to resect the triangular cartilage of the septum.

17. **Haematoma and Abscess of the Septum.**—Haematomata of the septum are in the majority of cases due to traumatism, the effusion of blood taking place between the cartilage and its perichondrium. They are more commonly met with in children than in adults and are frequently accompanied by signs of external violence. As the result of the entrance of micro-organisms through abrasions in the mucosa, the haematoma becomes infected, and is followed by rapid development of an abscess. Abscess of the septum may, however, also be due to such causes as syphilis, tubercle, erysipelas, typhoid fever, or smallpox, while in rare cases infection may spread from a carious incisor tooth and infect the mucosa of the septum at its attachment to the floor of the nose.

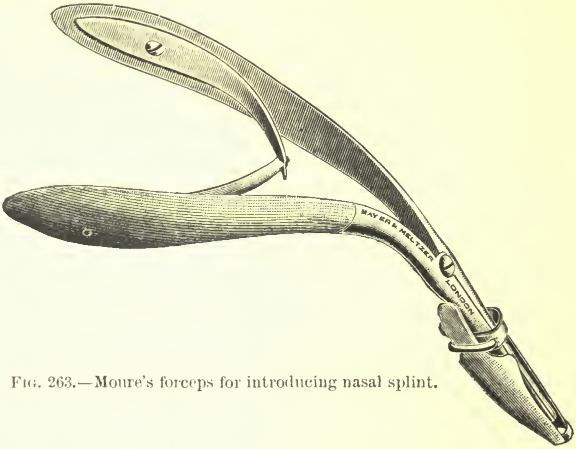

FIG. 263.—Moure's forceps for introducing nasal splint.

Pathology.—Effusion of blood into the nasal septum is generally associated with fracture of the bone or separation of the cartilage. Either the periosteum or perichondrium is its seat, and almost invariably it is bilateral, although perhaps more prominent on one side than the other. One peculiarity of blood extravasation in this region is its great liability to sepsis and its conversion into an abscess which may point either in the nose, on the lips, or below into the oral vestibule. Many bacteria are found in such abscesses the commonest being *staphylococcus, bacillus proteus vulgaris, bacillus coli communis*, and *bacillus pyocyaneus.* As a rule evacuation of the pus is followed by rapid healing, except in syphilitic cases when separation of sequestra may follow. Osseous lesions are exceptional.

Symptoms.—The symptoms produced by a haematoma are pain and discomfort accompanied by a varying degree of nasal obstruction. Should an abscess form, the pain becomes more severe, and is accompanied by certain external manifestations, such as redness and swelling. There is usually also an elevation of temperature and an increase of the existing nasal obstruction. If not relieved, the abscess may rupture with discharge of blood and pus, or it may become chronic and end in necrosis of the cartilage with perforation of the septum and falling in of the tip or bridge of the nose.

Diagnosis.—The history of an injury together with the appearance of a bilateral fluctuating and painful swelling situated in the anterior part of the nasal passage is generally sufficient to establish the diagnosis. From a suppurating gumma it is differentiated by the history and mode of onset, and also from the fact that a gumma is much less red and painful.

Treatment.—In the treatment of an haematoma absorption should be encouraged by the application of iced cloths, an ice-bag, or evaporating lotions over the bridge of the nose. Should formation of pus have taken place, an incision should be made under local or general anaesthesia upon one or both sides of the septum, and kept open with a strip of gauze or by the daily insertion of a probe until all discharge has ceased.

When necrosis of the cartilage has taken place a permanent perforation of the septum results which, if small, is of little moment, but if large may be followed by deformity should it occur in early life.

Many abscesses of the septum are not preceded by haematoma. A true pyogenic focus may originate in any of the numerous patches of lymphoid tissue with which the septum is studded, and in this case the swelling is asymmetrical and confined to one side. It may be traumatic in origin (*e.g.* from picking the nose, a foreign body) or may occur in connection with any of the specific fevers, and generally as a sequel in badly-fed and anaemic children living under insanitary conditions. The writer has seen an instance of tubercle bacilli in the pus without any constitutional infection, but the commonest infecting organism is the *bacillus coli communis* or one of the *staphylococci.*

18. **Rhinoliths.**—As a rule the nucleus of a rhinolith is a foreign body around which the earthy salts contained in the nasal secretions become

precipitated. Any circumstance, such as the existence of chronic rhinitis, sinusitis, a septal spur, or a deflection of the nasal septum, which tends to cause stagnation of secretion tends also to the formation and gradual building up of a rhinolith. In exceptional cases the nucleus of the "growth" has been found to be inspissated secretion or a clot of blood. Their gradual increase in size gives rise to increasing nasal stenosis, and at such times they cause external deformity. Their presence contributes to the retention of nasal secretion which becomes foetid and purulent. The mucosa in the immediate neighbourhood becomes oedematous and granular, and bleeds upon the slightest provocation.

Treatment.—If small they may be removed by means of a hook or sharp-pointed nasal forceps. Before removal is attempted, the mucous membrane should be anaesthetised with cocaine-adrenalin solution.

In children and nervous patients it is advisable to administer a general anaesthetic. If large it is advisable to break it up with forceps, and ultimately to syringe the nasal passages from the sound side with a weak antiseptic solution. To avoid the escape into the larynx of fragments of the growth, especially if the patient be under the influence of a general anaesthetic, plugging of the posterior nares is advisable. After the removal of the rhinolith the nasal mucosa rapidly returns to a normal condition.

Another and useful method of removal is to introduce the index finger into the post-nasal space and a pair of long nasal forceps through the anterior nares to grasp and extract the rhinolith.

19. **Congenital Occlusion of the Posterior Choanae.**—This is a remarkably rare affection. It may be unilateral or bilateral, membranous or bony and is almost invariably associated with irregularity in the development of the hard palate, *e.g.* a highly arched one.

The membranous or bony web, which varies considerably in thickness, is situated just within the entrance of the choana.

Symptoms.—The symptoms produced are those of unilateral or bilateral nasal obstruction, mouth breathing, snoring, restlessness at night, nasal speech, headache, and the facies of nasal obstruction.

Diagnosis.—The diagnosis may be made by inspection with the post-nasal mirror, by palpation with the finger in the post-nasal space, or by inspection and careful use of the probe through the anterior nares, or by a combination of palpation and the use of the probe.

Treatment.—Under general anaesthesia, with the finger introduced into the post-nasal space, the obstruction should be broken down with a sharp spoon.

After removal of as much of the obstructing tissue as is possible, a rubber tube should be passed through the anterior naris into the post-nasal space and retained *in situ* until healing has taken place.

In cases where subsequent contraction tends to take place, a portion of the posterior border of the vomer should be clipped away with a suitably shaped forceps (Symonds).

CHAPTER XLI

POST-NASAL CATARRH

Post-Nasal Catarrh.—In the majority of cases post-nasal catarrh is the result of a catarrhal rhinitis which has extended backwards from the nasal passages. It is characterised by the presence in the naso-pharynx of thick tenacious mucus or muco-purulent secretion, frequently difficult to dislodge, more especially so in the morning. In many cases crusts of the shape of an opened-out umbrella are expectorated. It may occur in an acute or chronic form.

Aetiology.—The various factors which induce attacks of catarrhal rhinitis are in many cases responsible for the onset of acute or chronic naso-pharyngitis. Cold, extremes of temperature, a dust-laden atmosphere, excessive smoking or drinking, atonic dyspepsia, and the presence of naso-pharyngeal adenoids are common causes. Plethoric individuals and those who suffer from chronic constipation are liable to attacks of post-nasal catarrh. Careful search should always be made for some *local* intranasal source of infection.

Accessory sinus suppuration, especially when present in the posterior ethmoidal or sphenoidal cells, is also prone to induce and to keep up naso-pharyngitis.

Symptoms.—The presence of a constant discharge, often tenacious and difficult to get rid of, is the most common symptom of post-nasal catarrh. When profuse the discharge may be seen to trickle down the posterior pharyngeal wall, which presents a glistening, slimy appearance. The voice is frequently husky from involvement of the laryngeal mucosa, or has a nasal intonation from deficient action of the musculature of the soft palate. Pain is seldom complained of. In severe cases retching or even vomiting results from the efforts made to hawk up adherent crusts.

Diagnosis.—Inspection with the post-nasal mirror, Hay's pharyngoscope (Fig. 51), or digital exploration as a rule settles the diagnosis. In many cases remnants of semi-atrophied adenoid growths are seen or felt which are in reality the exciting cause of the catarrh, and which when removed bring about its disappearance. The presence of pus in the naso-pharynx and upon the posterior ends of the middle and superior turbinals is generally indicative of accessory sinus suppuration, the catarrhal condition of the naso-pharyngeal mucosa being a secondary phenomenon. In all such cases transillumination of the accessory sinuses should be employed.

Prognosis.—In recent and mild attacks of nasopharnygeal catarrh the prognosis is good, whereas in chronic cases, especially amongst those living in damp and unhealthy surroundings, or who follow unhealthy occupations, a complete cure is seldom obtained.

Treatment.—Attention should be directed to the state of the general health, to the surroundings of the individual, to the character of his occupation, and to his habits.

In plethoric individuals alkaline aperients, exercise, and abstention from alcohol and tobacco are indicated; whereas in those who are anaemic tonics, rest, and change of air are called for. A course of cod-liver oil is often beneficial.

Locally the main indication is cleansing of the naso-pharyngeal mucosa with alkaline antiseptic lotions, either by means of Wingrave's syringe or one or other form of post-nasal spray. When the mucosa is red, swollen, and oedematous the local application with a post-nasal brush of astringent pigments is useful, *e.g.*, nitrate of silver (40 to 60 gr. to 1 oz.), chloride of zinc (xx. to xxx. gr. to 1 oz.), perchloride of iron (2 dr. to 1 oz.), or sulphate of copper (xxx. gr. to 1 oz.).

When crusts are adherent a preliminary spraying with a 6 per cent peroxide of hydrogen solution is useful.

Definitely thickened mucous membrane and remnants of adenoid growths should be scraped under local or general anaesthesia, and infected accessory sinuses drained.

CHAPTER XLII

POST-NASAL GROWTHS

Naso-pharyngeal Adenoids.—Adenoids are masses of lymphoid tissue situated in the post-nasal space. They are representatives of similar elements found in many other parts of the body in connection with special functions, *e.g.*, the eyes have small masses situated below the palpebral conjunctiva; in the nose they are scattered over the middle turbinals and septum; in the tongue they occupy its posterior or pharyngeal region behind the circumvallate papillae; in the fauces they constitute the faucial tonsils; and in the larynx they exist as small masses and are found in the ventricular bands. Passing down the digestive canal small discrete nodules are seen in the posterior or pharyngeal wall often referred to when prominent as "granular pharynx"; as large clusters in the small intestine they are called "Peyer's patches"; almost filling an elongated tube they constitute the appendix; while irregular islands are seen in the stomach. Finally, as discrete nodules they form the solitary follicles of the colon accentuated at the end of the rectum.

The post-nasal group or *adenoids proper* anatomically belong to the ear or Eustachian cleft since they occupy the post-area of the pharyngeal vault, and sometimes involve the ostium of the Eustachian tube. The chief mass is centrally situated, but isolated tufts may be found in almost any part of the post-nasal space, least frequently in Rosenmüller's fossae.

Adenoids consist of loose lymphoid tissue in which are more compact masses containing an extra large number of epitheliod cells called follicles, the whole being covered with ciliated columnar epithelium, dipping down into furrows, and giving it the appearance of brain cortex when seen *in situ* or when removed *en masse* (Fig. 264). They thus resemble the faucial tonsils, but have their lacunae arranged vertically. At birth they are, as a rule, very small, but at the end of twelve months they may assume considerable size, and if inflamed may completely fill the post-nasal space. This hypertrophy may be the result of an acute process or of persistent chronicity. The effect of chronic inflammation is seen by the presence of well-marked masses of plasma cells and considerable irregularity of disposition of the follicles and lacunae, while the covering epithelium is often transformed into short pallisade cells or even stratified squames.

The fact that adenoids, like other islands of lymphoid tissue, are of small size in early infancy and grow rapidly after the first year is of great significance, since if their removal be undertaken during the first four or five years of childhood it must be thorough, otherwise what is left will continue to grow and a so-called "recurrence" result.

By reason of their size, situation, great instability, and vulnerability adenoids exercise both a direct and an indirect influence upon the antro-tympanic cavity. It must be remembered, however, that adenoids *per se* are not necessarily morbid structures to be removed simply because they happen to be present. The question of morbid size is very much one of proportion between the adenoid tissue itself and its containing chamber. It is *disproportion* which should in a great measure determine their removal, *e.g.*, a relatively small and "quiet" adenoid in a diminutive naso-pharynx will demand the surgeon's attention, whereas in a roomy cavity it may be ignored.

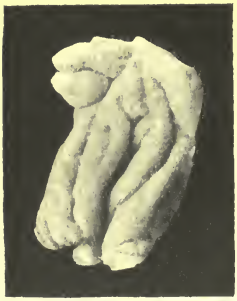

FIG. 264.—Adenoid vegetation, showing large median cleft.

Adenoids may affect the ears in several ways. By their size they may mechanically interfere with the ventilation and drainage of the middle ear and nasal region. This interference may be constant or only intermittent, for not only may the adenoids themselves vary in size, but the adjacent mucous membrane, particularly the posterior end of the inferior turbinals, may temporarily swell. Further, morbid adenoids are specially prone to infection, and may keep up a state of naso-pharyngeal sepsis which at any moment may extend to the ear. The writers have shown that the naso-pharynx of healthy people, young and old, is practically sterile, but that in cases of middle-ear disease, troublesome adenoids, sinusitis, atrophic rhinitis, etc., it is invariably infected by bacteria.

Further, it has been shown that in the majority of cases of ear discharge the bacteria discovered are identical with those of the mouth and naso-pharynx.

Adenoids themselves may be the seat of morbid changes similar to those found in the faucial tonsils, such as simple, fibrous, and seroedematous enlargement, lacunar, and interstitial inflammation, cholesteatomatous or cystic degeneration, secondary and probably primary tuberculosis, etc., all of which conditions afford excellent facilities for other bacterial growth. Hence their presence is fraught with danger to the integrity of the middle ear.

They are, as a rule, found in children under ten years of age, and more frequently among the children of the poorer classes. They show a marked tendency to atrophy between the ages of fifteen and twenty, and are rarely found in persons over twenty-five years old. Furniss Potter[1] records a case in a patient aged forty-seven, and the writer has removed a large growth in one patient aged forty-nine and in another aged sixty-three.

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[1] *Journal of Laryngology*, 1900, xv., p. 296.

They occur with almost equal frequency in the male and female sexes and are often hereditary, while several members of the same family may be affected. They are more common in children with small and finely-shaped nostrils than amongst those with broad and well-developed nasal passages.

They also occur much more frequently in cold and damp than in warm and dry climates, and in town-bred children more often than amongst those brought up in the country. Certain races, *e.g.* the Hebrew race, are specially prone to suffer from adenoid vegetations.

Tuberculous and syphilitic children are undoubtedly susceptible to adenoid hypertrophy. Recurring head catarrhs, scarlet fever, measles, whooping cough, diphtheria, and various forms of septic sore throat are prone to induce hypertrophy.

Diagnosis.—In many cases a diagnosis may be made by simple inspection—the narrow nasal passages, the inactive nasal dilators, the half-open mouth, the stupid and vacant expression, combined with a history of recurring head colds, earache, and deafness being highly suggestive of their presence.

To confirm the diagnosis the naso-pharynx should be inspected by means of a post-nasal mirror or Hay's pharyngoscope, or by digital exploration with the index finger.

Inspection by means of a mirror, although frequently very difficult in children, should always be attempted before resort is had to digital exploration, which is a painful proceeding and tends to unnerve the young.

By means of the post-nasal mirror a fairly accurate idea of the amount of growth present and its relation to the mouth of the Eustachian tubes may be formed. The larger the growth the less seen of the posterior border of the septum nasi.

Should digital exploration be necessary, the child's head, covered by a towel, is placed in the surgeon's left arm-pit and held there firmly. With the thumb of the left hand the patient's cheek is gently pressed into the mouth between the teeth in such a way that the child is unable to close the mouth without first of all biting himself. The surgeon's right index finger protected by a rubber guard is then passed rapidly behind the soft palate and swept across the naso-pharyngeal vault. By so doing an estimate of the size, consistence, and contour of the growth is rapidly made, and also whether the posterior ends of the turbinals are enlarged or not.

Differential Diagnosis.—Certain other post-nasal affections simulate the presence of adenoids, and require to be carefully differentiated, *e.g.* naso-antral polypus, naso-pharyngeal fibroma or fibro-sarcoma, moriform hypertrophy of the posterior ends of the inferior turbinals, meningocele, congenital occlusion of the posterior nares, and imperfect development of the choanae. Recently, attention has been directed in certain cases to a marked forward prominence of the bodies of the second and third cervical vertebrae, and the presence of a vomerine ridge,[1] causing such a degree of narrowing as to suggest the presence of adenoid growths.

Treatment.—The question as to whether adenoids should be removed surgically or treated by expectant methods is one calling at times for careful consideration. The fact that adenoids are present is not of itself sufficient reason to justify their removal.

The question of *disproportion* or the size of the adenoid mass in relation to the size of the naso-pharyngeal chamber, and the involvement or otherwise of the middle ears, must be carefully considered.

When the adenoid mass is small and the naso-pharynx roomy, and when respiration is slightly, if at all, interfered with, and when no ear trouble is present, no operative interference is called for. When, on the other hand, the amount of adenoid tissue is large, the naso-pharyngeal space small, and the middle ears affected, operation should be performed without delay. The writers are, moreover, of the opinion that whenever the middle ears are affected, even in the slightest degree, and whether there is any obstruction to respiration or not, operation is called for to maintain the sense of hearing.

Expectant Treatment consists mainly in measures designed to improve the general health, to increase the powers of resistance, and consequently to help to ward off recurring attacks of catarrh. Change of atmosphere to dry, bracing, mountain air, or residence at a seaside resort where there is plenty of warmth and sunshine, combined with tonics, is helpful. The local application of astringent pigments or syringing with a mild, alkaline, antiseptic lotion, by relieving catarrhal symptoms, tends, in conjunction with the lapse of time, to assist in retrogressive changes taking place.

Breathing exercises, which have in some quarters been extolled as a means of cure are, in the experience of the writers, of no use whatever in those cases where a mass of organised adenoid tissue is present, but are an excellent adjuvant after operation in teaching the acquirement of the correct act of respiration.

Operative Treatment.—Removal of adenoids may be accomplished with the patient sitting upright in a chair, lying upon his back with the head extended over the end of the operating table, or with the patient lying upon his side. The operation may be performed without an anaesthetic or under chloroform, ether (open or closed method), A.C.E. mixture, nitrous oxide (with or without oxygen), or ethyl chloride anaesthesia. Many operators prefer the short anaesthesia of nitrous oxide or ethyl chloride; others ether, on account of its greater safety as compared with chloroform. The writer's experience is mainly limited to chloroform anaesthesia, pushed quite sufficiently to keep the patient quiet and insensitive to pain, but not to such a degree as to abolish either the pharyngeal or laryngeal reflexes. Preliminary preparation consists in the administration of a laxative the day before operation and 2 ounces of bovril or oxo four hours prior to operation, which, if possible, should be performed the first thing in the morning.

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[1] *Adenoids*, Wingrave, Bailliere, Tindall, and Cox, 1904.

When a sufficient degree of anaesthesia has been induced, the patient's head, previously encircled with a towel wrung out of ice-cold sterilised water is drawn over the edge of the table and a mouth-gag inserted. The operator should then carefully palpate the naso-pharynx, and examine the posterior pharyngeal wall by means of reflected light for the presence of any abnormal blood-vessels coursing behind the posterior faucial pillars.

The tongue is then depressed and kept depressed by the surgeon's left forefinger. An adenoid curette (Fig. 265), held firmly in the operator's right hand (St. Clair Thomson, Beckmann), is then introduced behind the soft palate and in the middle line until it is in contact with the posterior border of the bony septum. With firm pressure and with a forward and downward sweeping movement, the adenoid mass is cut away from its attachment to the naso-pharyngeal vault. After its removal the naso-pharynx is re-examined digitally, and any tags or remnants of growth removed with forceps or scraped away with curette or ring-knife introduced through the mouth.

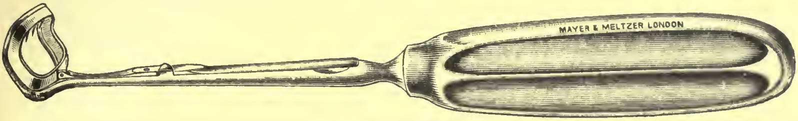

Fig. 265.—St. Clair Thomson's adenoid curette.

Immediately after the removal of the growth the patient is drawn up upon the table and turned over on his side, while cold water may or may not be poured over the head. Haemorrhage is in this way usually readily controlled. The fact that the patient has not been so deeply under the anaesthetic as to abolish his pharyngeal and laryngeal reflexes, permits of his coughing up any blood, and also saves sponging out the pharynx with the almost inevitable bruising of soft palate, faucial pillars, etc.

Adenoids may also be removed by means of Loewenberg's post-nasal forceps, the mass being avulsed piecemeal and by force from its attachment to the naso-pharyngeal vault. This method is now seldom employed, except in the case of very young children, where it is difficult, if not impossible, to use a curette efficiently. When employed, St. Clair Thomson's modification of Juracz's post-nasal forceps is a useful instrument for the purpose.

Removal by ring-knives passed through the anterior nares as originally advocated by Mayer, and also the use of the cold-wire snare or cauterisation with the electro-cautery are methods attended by considerable risk, and seldom satisfactory.

The chief danger attending the operation is from the anaesthetic.

Whenever possible, the services of a skilled anaesthetist should be procured, and the patient carefully prepared for operation. The more rapidly and the more thoroughly the operation is performed the less the risk.

Haemorrhage, although at times fairly brisk, is seldom troublesome, and is, as a rule, readily controlled by raising the head, the application of cold-water cloths to the head, or pouring cold water over it. Sponging the fauces and naso-pharyngeal space should be avoided as far as possible, not only because it seems at times to rather encourage bleeding, but also because it is prone to cause bruising of the soft tissues, *e.g.* palate, faucial pillars, etc. Frequently a tag of semi-detached tissue will be found to be responsible for the bleeding. Should haemorrhage, however, prove really troublesome, the patient's head should be kept well raised, and ice applied to the sides of the neck and the top of the head. All clots should be blown out of the nasal passages or drawn out with forceps, so as to permit of the free ingress of air, and ice-cold water or a weak solution of iced adrenalin dropped by means of a pipette into the anterior nares. The application of strong styptic solutions and packing of the naso-pharyngeal cavity should be avoided, the former on account of the sloughing of tissue produced, and the latter on account of the risk of inducing middle-ear sepsis.

In using the curette, care should be taken to see that it is introduced well behind the uvula, otherwise the uvula, which is at times drawn up against the posterior pharyngeal wall by sudden muscular contraction on its introduction, may be seriously bruised or torn.

With the curette injury is seldom done to the posterior border of the septum or to the Eustachian cushions, if kept in the middle line, whereas formerly, when post-nasal forceps were more in use, such accidents were by no means uncommon.

As a rule, no after-treatment is called for. The patient should be kept in bed in a well-ventilated and warm room for two days, in the house for two days, and if weather permits, allowed out upon the fifth day.

Syringing the nasal passages or the insufflation of powders should be absolutely interdicted. In other words, the more the patient is left to the *vis medicatrix naturae* the better.

Inflation of the middle ears should be postponed for from eight to ten days until cicatrisation of the raw surfaces in the naso-pharynx has taken place.

Tumours of the Naso-pharynx.—Innocent and malignant new growths are found in the naso-pharynx giving rise to nasal obstruction, profuse discharge, intermittent attacks of tubal catarrh, sero-mucous or purulent catarrh of the tympanic mucosa, progressive deafness, and otalgia.

Next to granulomata and fibroid tumours endotheliomata are met with more frequently than any other form of neoplasm.

Naso-antral Polypus.—This form of growth has been shown by Killian[1] to take its origin from the mucosa lining the maxillary antrum. It is met with at times in cases where an accessory ostium maxillare is present. It has a long delicate pedicle (Fig. 266), and by gradual growth passes from the antrum into the corresponding nasal passage and so into the post-nasal space, where it assumes a globular shape. Owing to increase in size and pressure upon the edges of the ostium a varying amount of absorption of bone takes place.

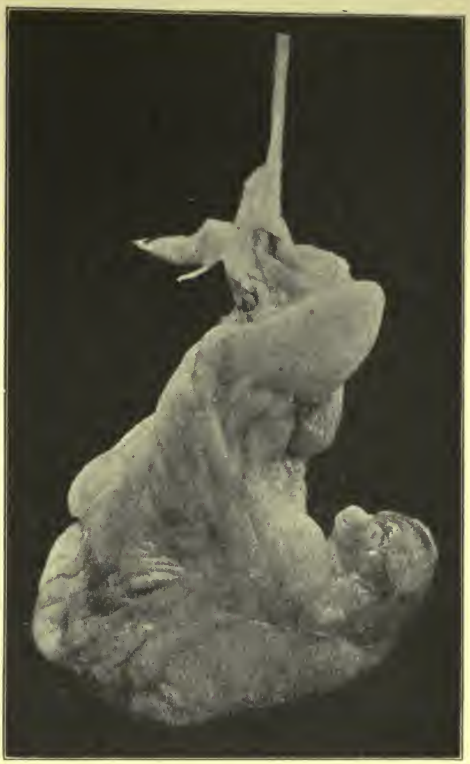

Fig. 266.—Large naso-antral polypus removed by radical operation through the canine fossa.

Pathology. — This particular kind of polypus exhibits large numbers of gland acini and ducts, derived from the margin of the ostium, which is the only region of the sinus supplied by glands.

Treatment.—Avulsion of the growth may be effected by snare or forceps. Under such circumstances, however, recurrence is prone to take place. A more effective plan is to open the antrum from the canine fossa, and under efficient illumination to search for the attachment of the pedicle. When found the growth is forcibly avulsed, and its site of attachment cauterised with pure phenol or the electro-cautery.

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[1] *Lancet*, 14th July 1906, p. 81 ; A. Brown Kelly, *Lancet*, 9th January 1909.

CHAPTER XLIII

HYPERTROPHY OF THE FAUCIAL TONSILS

Hypertrophy of the Faucial Tonsils.—Hypertrophy of the faucial tonsils, so frequently associated with post-nasal adenoids, leads to changes in the tubo-tympanic axis either from direct mechanical pressure, from extension of catarrhal inflammatory processes, or from interference with the musculature regulating the ventilation of the middle ear. Their presence also, more especially when their crypts are diseased, leads to the production of constantly recurring attacks of septic pharyngitis with all its possibilities. The influence of enlarged faucial tonsils upon the mechanism of the auditory apparatus is, however, not nearly so important as that exercised by the presence of naso-pharyngeal adenoids. The healthy tonsil is about one-half of an inch in length and one-half of an inch in width and thickness. Its free surface is perforated by from twelve to fifteen small openings or crypts, which run through the substance of the gland, their blind extremities resting upon the fibrous capsule which separates the tonsil from the superior constrictor of the pharynx.

The crypts are of great clinical importance, because it is within them that decomposing secretion and bacteria find a habitat. The resulting irritation gives rise to various forms of angina, which, in turn, may and do extend by continuity of tissue to the middle ear. When septic they also form important portals of infection, giving rise to inflammatory or tuberculous enlargement of the deep cervical glands.

It should be borne in mind, however, that it is not so much the *size* of hypertrophied tonsils as their *septicity* which is of real clinical importance. Hence the submerged are frequently of more importance than the enlarged and fibrous tonsils which project into the pharynx.

Seccombe Hett[1] has described six clinical varieties: (1) the embedded tonsil, (2) the projecting tonsil, (3) the flat tonsil, (4) the hanging tonsil, (5) tonsils with preponderance of anterior, middle, or posterior masses, or a combination of these, (6) the tonsil with marked lingual prolongations.

When interfering with the mechanism of the Eustachian tube or with the ventilation of the middle ear, or when directly responsible for recurring attacks of tubo-tympanic catarrh, they should be dealt with surgically and treated upon those same general principles which underlie the treatment of enlarged lymphatic glands, which in fact they are. In such cases it is practically useless to merely slice off that portion of the tonsil which projects between the faucial pillars (tonsillotomy) and leave the bases of infected crypts behind. The surgical procedure is to enucleate the diseased gland *in toto* (tonsillectomy). This may be accomplished by means of the finger, or by one or other method of cutting operation.

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[1] *Lancet*, 13th February 1909.

1. *Finger Enucleation.*—The patient is placed under the influence of a general anaesthetic, and a mouth gag introduced between the molar teeth. The index or index and middle finger of the right hand is introduced into the mouth with its palmar surface against the anterior faucial pillar. By an upward and downward movement of the finger-nail the capsule is torn through throughout the whole length of the isthmus. The same manipulation is carried out along the posterior faucial pillar. The tonsil, now partially free, is then pulled forwards and inwards into the mouth by means of a catch forceps, and then gradually stripped by the finger from the fibrous bed which separates it from the superior constrictor of the pharynx. Towards the lower pole a stout band of fibrous tissue is encountered which requires division with scissors or guillotine.

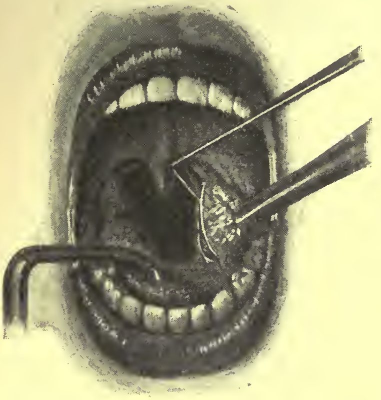

FIG. 267.—West's operation. Tonsil grasped with toothed forceps and separated from the posterior pillar with an L-shaped knife.

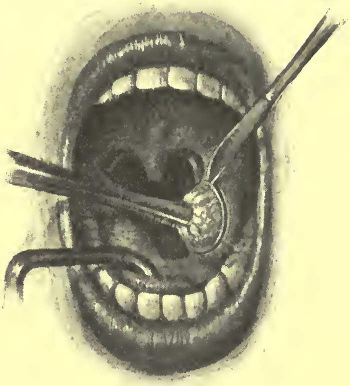

FIG. 268.—West's operation. Tonsil pulled towards middle line and an incision made from below upwards to meet incision first made.

2. *West's Operation.*[1]—The tonsil is grasped and pulled forwards with a suitable pair of forceps, and completely separated from the posterior pillar with an L-shaped knife (Fig. 267). Still drawing the tonsil forwards and towards the middle line, an incision is made with a straight knife, beginning below the tonsil posteriorly where the first incision ends, and cutting round it until the first incision is met again at its upper extremity (Fig. 268). The tonsil is then pulled towards the centre of the mouth, and its separation from the underlying bed of connective-tissue effected by working from above downwards with the knife between its capsule

[1] *Johns Hopkins Hosp. Bull.*, November 1908.

and the superior constrictor of the pharynx (Fig. 269). Should haemorrhage prove troublesome the dissection may be continued by entering the knife into the incision below the tonsil, and cutting from below upwards.

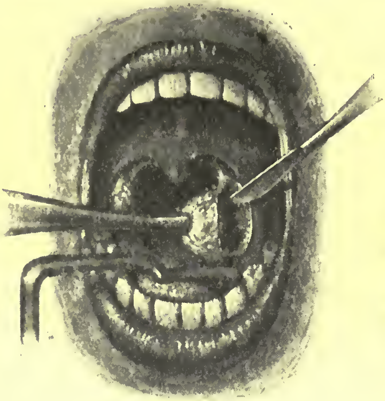

FIG. 269.—West's operation. Tonsil now freed and pulled forwards and dissected from above from the loose connective-tissue which separates its capsule from the superior constrictor muscle.

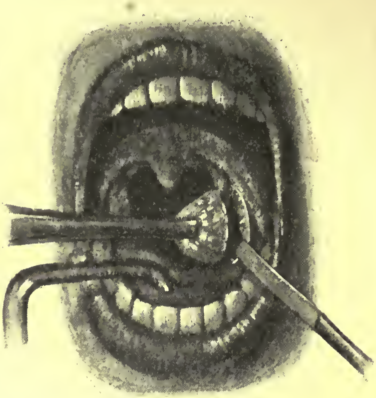

FIG. 270.—West's operation. Final step in the enucleation of the tonsil.

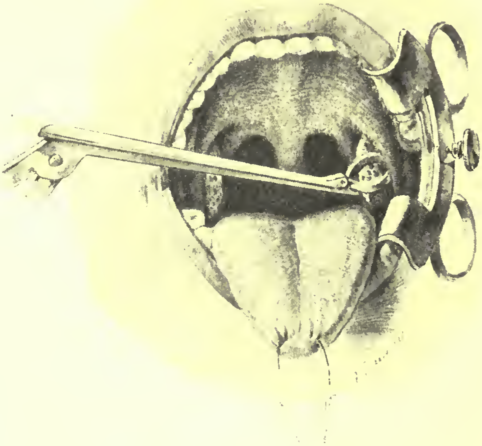

FIG. 271.—Waugh's operation.
Embedded tonsil grasped by ring forceps and drawn towards the middle line.

Waugh's Operation.[1]—The patient is placed upon the table in the recumbent position, with a sand-bag between his shoulders, and with the head slightly extended. A silk thread is passed through the tongue for

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[1] *Lancet*, 8th May 1909.

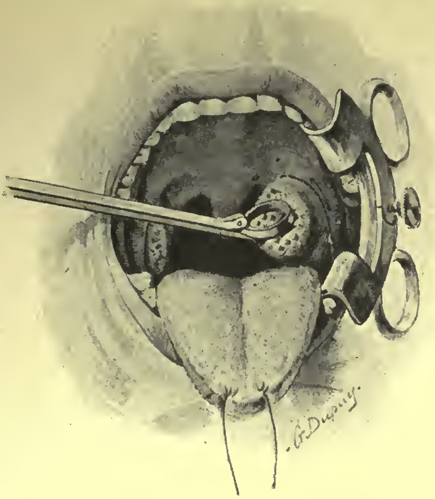

FIG. 272.—Waugh's operation. Tonsil drawn inwards with the embedded part bulging beneath the anterior pillar of the fauces. The dotted line indicates the line of incision down to the capsule.

traction purposes, and a gag introduced between the last molar teeth. The tonsil is seized with a Hartmann's conchotome, and drawn towards

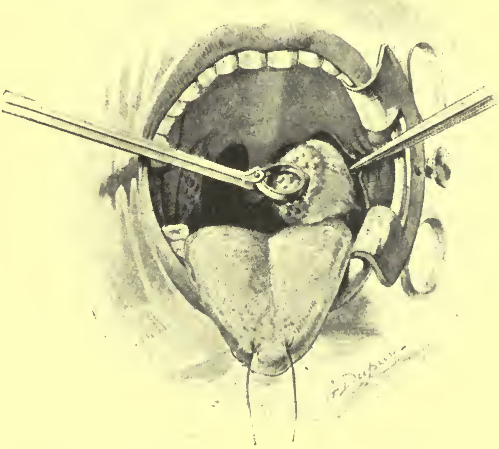

FIG. 273.—Waugh's operation.
Reveals the large encapsuled part of the tonsil shelled out of its pharyngeal bed.

the middle line (Fig. 271). An incision is made immediately external to the internal margin of the anterior faucial pillar, where it blends with the surface of the tonsil, extending throughout its whole length (Fig. 272). This incision displays the capsule of the tonsil, which appears as a bluish-white surface. The conchotome is then readjusted so as to get a still firmer hold of the tonsil, and the anterior pillar is drawn out by a pair of fine-toothed forceps (Fig. 273). The tonsil is then readily separated from its bed, partly by traction, and partly by separating the loose cellular tissue, which intervenes between the bed of the tonsil and the pharyngeal wall, by means of forceps or blunt-pointed curved scissors.

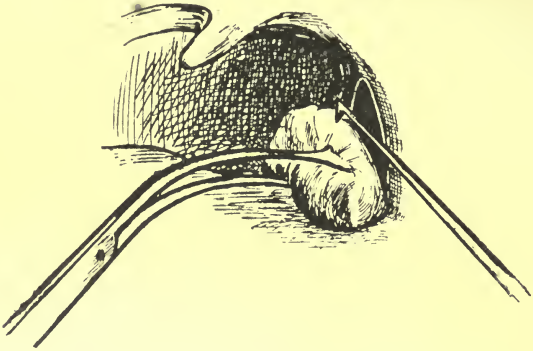

FIG. 274.—Division of the so-called capsule with author's right-angled bistoury.

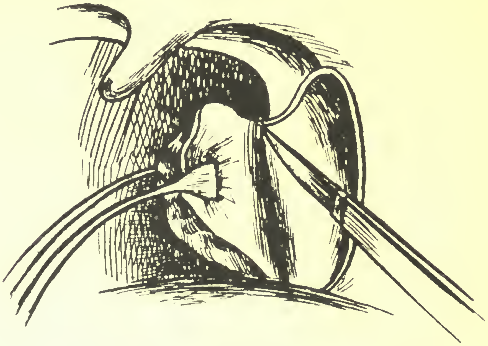

FIG. 275.—Separation of tonsil from its so-called capsule.

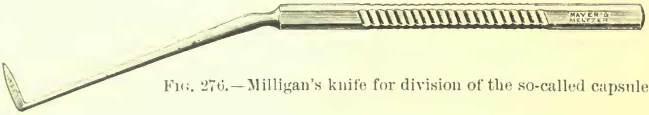

FIG. 276.—Milligan's knife for division of the so-called capsule.

Milligan's Operation.[1]—To divide the capsule a right-angled knife

[1] *Medical Chronicle*, May 1910.

(Fig. 276) is inserted under the anterior faucial pillar, and swept upwards and downwards throughout the whole length of the tonsillar isthmus (Fig. 274).

The same manipulation is practised along the limits of the posterior pillar, so that the capsule is completely divided. The tonsil, now attached to the underlying superior constrictor of the pharynx only by a bed of connective tissue, is shelled out in children by the finger or guillotine, in adults by the finger, guillotine, knife, or scissors, being meanwhile drawn towards the centre of the mouth by means of a special pair of forceps (Fig. 275).

The success of the enucleation is noted by the appearance of the cellular tissue covering the base of the excised organ (Fig. 277). Recent observations by one of us upon enucleated tonsils have shown that the central or equatorial area of the tonsil is always closely connected with the constrictor muscle, so that many of its fibres are torn and remain attached to the excised tonsil.

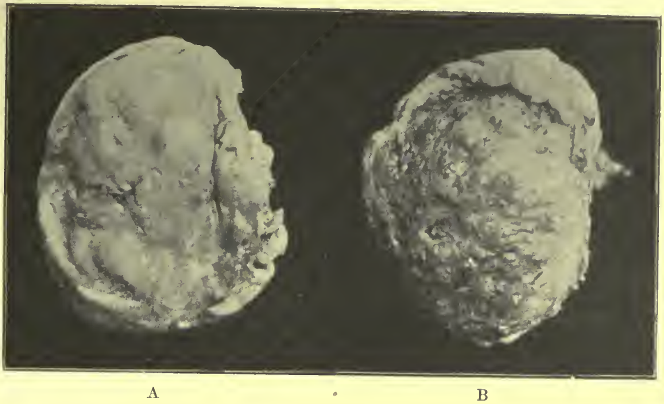

FIG. 277.—Enucleated tonsils. A, Faucial surface of tonsil showing mouths of crypts and capsule; B, cervical surface of tonsil showing areolar and elastic tissue from bed of capsule.

The writer has recently made an exhaustive examination of tonsils removed by various enucleation methods. It was found that the gland was separated from its fossa by loose fibro-elastic tissue in part only. Over a variable area corresponding with its posterior and outer aspect this tissue was wanting, the tonsil elements being closely blended and mixed with muscle fibres, so that it was impossible to remove the tonsil without a considerable portion of muscle fibre also. This was especially marked in the equatorial region, where the so-called capsule is entirely absent. The connective tissue of the fossa was further found to contain a striking proportion of elastic fibres, which were often prolonged for some distance into the stroma of the gland—an interesting feature not previously recorded. Below the inferior pole of the tonsil and embedded in its connective tissue sheath considerable numbers of mucous glands were found in every case, very few and at times none at all occurring at the opposite or superior pole (Fig. 278).

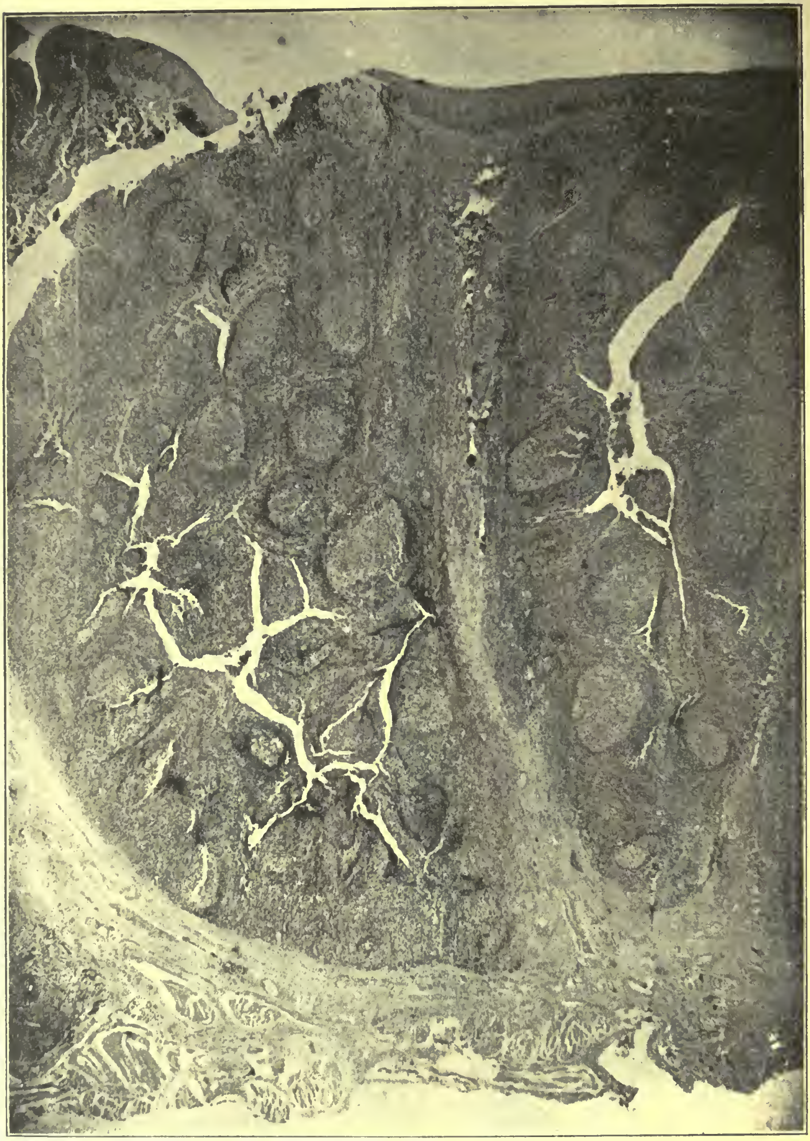

FIG. 278.—Section of enucleated tonsil, showing muscular tissue in the equatorial area.

To remove tonsils under local anaesthesia, the tonsil, the anterior and posterior faucial pillars, the posterior pharyngeal wall, and the soft palate should be painted with a 10 per cent solution of cocaine, followed by spraying with a 1 to 1000 solution of adrenalin chloride. When surface anaesthesia has been produced deep anaesthesia may be effected by injecting a few drops of a 1 to 2 per cent solution of cocaine, to which an equal quantity of 1 to 1000 adrenalin solution has been added into the base and apex of the tonsil, and also into its substance at about the level of the middle of the anterior faucial pillar.

The surgeon then introduces the forefinger of his left hand into the patient's mouth, and makes use of it partly as a tongue depressor and partly as a means of steadying the lower jaw. Or the patient may himself help to keep the tongue depressed with a Turck's spatula. One or other form of guillotine (Matthieu's, Kyrick's, or Behag's) is then slipped over the projecting tonsil. At the same time an assistant makes counter pressure just below and behind the angle of the jaw, so as to force the tonsil inwards towards the middle line. The blades of the instrument are then closed, with the result that the tonsil, if not enucleated, is cut through near its base.

The practical objections to tonsillotomy are that it does not effect complete removal of the gland, the diseased crypts being merely cut through at a varying distance from the surface, and that recurrence is exceedingly common.

Haemorrhage, following operations upon the tonsils, is rarely dangerous, although for a time it may prove troublesome. As a rule, it is arterial. Severe bleeding has, however, been recorded as coming from the tonsillar plexus of veins. When arterial, it arises either from the tonsillar artery, a branch of the facial, or from a large artery in the anterior pillar. Severe haemorrhage is more common in males than in females. Female patients, however, stand the loss of blood better than males on account of their greater powers of blood-making. In weakly and delicate children even moderate haemorrhage may be attended by symptoms of severe collapse.

If possible, the spurting artery should be seized and ligatured. If not possible to apply a ligature it should be clamped, and the forceps left *in situ* for twelve hours or even more; or the isthmus may be packed with gauze soaked in adrenalin solution, and the anterior and posterior pillars sewn together. If bleeding comes from the anterior pillar its complete division with scissors will generally stop the flow. The application of strong astringent preparations, *e.g.* perchloride of iron, turpentine, is undesirable, as it favours the formation of large sloughs whose subsequent separation is frequently followed by severe secondary haemorrhage.

Following the removal of tonsils in children it is advisable to make daily applications of glycerine of carbolic acid, glycerine of borax, or perhydrol solution to the raw surfaces; in adults to recommend the frequent sucking of formamint or formathol tabloids.

Tonsillotomy Rash.—In exceptional cases, a rash of a roseolar or erythematous character develops upon the second or third day after operation. It may spread along the neck, chest, and abdomen, and is frequently followed by the desquamation of very fine epidermal cells. It closely resembles, if it is not identical with, surgical scarlatina.

Wyatt Wingrave observed 30 cases in seven years, 10 occurring in males, and 20 in females.

Anaesthetics in Tonsil and Adenoid Operations.—The particular anaesthetic which should be employed is a matter of the greatest importance. Judging from experimental evidence, it would seem that chloroform possesses nearly seven times the lethal capacity of ether, hence ether would *a priori* appear to be the anaesthetic to select. The enhalation of ether, while stimulating the circulation, interferes, however, considerably with the performance of the operation in addition to producing vascular engorgement of the naso-pharynx, and an excessive secretion of mucus in both pharynx and lungs. This is more especially found to be the case in young children.

Chloroform, on the other hand, although not so free from danger, is more easily administered, is less irritating than ether, and does not stimulate any excessive flow of mucus. It does not, however, stimulate either circulation or respiration. In the initial stages of its administration, it is apt to cause marked depression as is evidenced by quiet respiration, feeble pulse, and pallor of the face.

According to A. Wilson[1] these various disadvantages may be overcome by the use of the A.C.E. or C.E. mixture (two parts of chloroform to three of ether), or by commencing with ether dropped upon lint, and when both circulation and respiration are active, to cautiously replace the ether with chloroform. The degree to which the anaesthesia should be pushed is of great importance in relation to the question of haemorrhage. In superficial anaesthesia, the patient, while remaining quiet, is able to cough up blood and mucus collecting in the throat, whereas in profound anaesthesia the operator has to be constantly on the alert to see that no blood or mucus is drawn into the respiratory passages.

When there is much haemorrhage, it is better for the patient to be deeply under the anaesthetic, to be a purely passive agent, and for the surgeon to be alone responsible for mopping up blood and secretion.

The immediate cause of death in chloroform poisoning is failure of the circulation due to vaso-motor or cardiac paralysis. In the former the heart fails from want of fluid upon which to contract; in the latter from paralytic over-distension.

Vaso-motor paralysis is indicated at quite an early stage of the administration by pallor of the lips, feeble pulse, exaggerated respiration, and widely dilated pupils. This is followed by sudden cessation of respiration, which occurs, however, only after the circulation has already given out. Any undue acceleration of respiration in the initial stages of the anaesthesia should be looked upon with grave suspicion, and should the pulse begin to flag the patient should immediately be placed in the recumbent position, and forcible artificial respiration practised. In cases of cardiac paralysis with marked cyanosis, artificial respiration should be combined with raising the patient into the sitting posture so as to relieve the greatly over-distended right ventricle.

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[1] *Medical Chronicle*, May 1910.

CHAPTER XLIV

SUPPURATIVE DISEASE OF THE NASAL ACCESSORY SINUSES

Suppurative Disease of the Nasal Accessory Sinuses, when chronic, is usually a poly-microbic infection, but when acute only one or two varieties of bacteria are present. It is a frequent cause of maintaining and at times of inducing purulent otitis media, infective organisms being conveyed to the middle ear by way of the Eustachian tube.

Infective disease of the anterior group of accessory sinuses is not so prone to induce middle-ear complications as is disease of the posterior group.

The causes also, which induce infective disease of the middle-ear tract are similar to those which induce accessory sinus suppuration, *e.g.* catarrhal affections of the upper respiratory tract, the exanthemata, influenza, typhoid fever, diphtheria (p. 198); while in addition the responsible organisms are in the main the same, viz.—*streptococci*, *pneumococci*, *staphylococci*, and Gram + and − *diplococci.*

For clinical purposes the nasal accessory sinuses may be divided into two main groups, anterior and posterior, the ostia of the former, the frontal sinus, anterior ethmoidal cells, and maxillary antrum, opening into the middle meatus; those of the latter, posterior ethmoidal cells, and sphenoidal sinus opening into the superior meatus.

Acute catarrhal inflammation of the mucosa lining any one of the accessory sinuses runs a rapid course, ending either in complete resolution, or in the production of pus. From the point of view of infection of the middle-ear tract only purulent disease will be considered, the reader being referred to treatises upon diseases of the nose for information regarding acute catarrhal affections, new growths, etc.

In health the accessory sinuses are sterile, but as the result of many and varied intra-nasal lesions they are prone to become infected. In the case of the maxillary antrum, disease of the molars, and occasionally also of the bicuspid teeth, acts as a frequent exciting cause.

Owing to the intricate arrangement of the cavities and the position of their ostia, free drainage is prone to be impeded, with the result that purulency is favoured. In many cases the lesion may be confined to one cavity, in others two or more become infected either simultaneously, or as the result of the infective process spreading. When the ostium of the infected sinus remains patent and permits of discharge escaping into the nasal passage, the condition is termed "latent" empyema, when it is closed "manifest" empyema, and when at one time open and at another closed "alternating" empyema.

Considerable divergence of opinion exists as to the frequency with which the sinuses are affected. In the writers' experience, the relative order of frequency is: (1) anterior ethmoidal cells, (2) maxillary antrum, (3) posterior ethmoidal cells, (4) frontal sinus, (5) sphenoidal sinus.

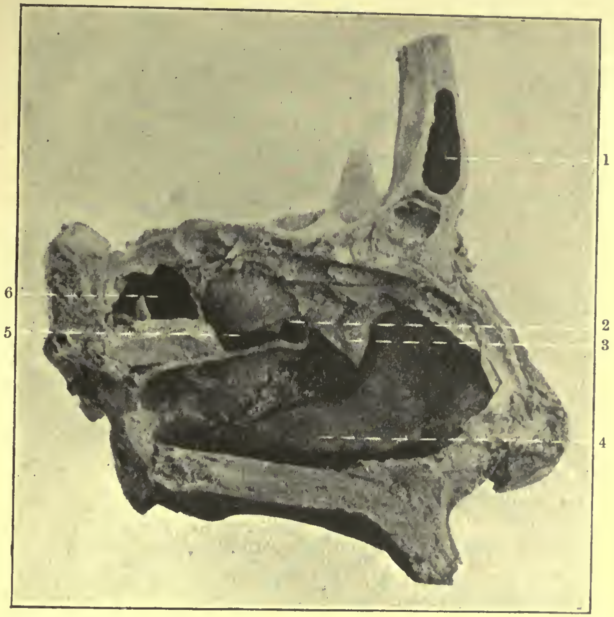

FIG. 279.—Section of nose. The greater part of the middle turbinal has been removed to show the bulla ethmoidalis, the ostium maxillare, and the lower end of the infundibulum. (1) Frontal sinus, (2) ostium maxillare, (3) anterior end of middle turbinal, (4) inferior turbinal, (5) bulla ethmoidalis, (6) sphenoidal sinus.

The pathological changes resulting affect not only the mucosa lining the sinus, but also that of the corresponding nasal passage, and consist in thickening and oedema of the mucoperiosteum, formation of oedematous buds of granulation tissue and definite polypi. As the disease progresses the underlying bone becomes implicated, with the result that caries is induced. Actual necrosis of bone is, however, uncommon, except in those cases due to syphilitic and tuberculous infection.

As the result of caries the bony partitions (of the ethmoidal labyrinth in particular) become broken down, so forming a cavity of varying size, full of granulation tissue, purulent debris, etc. The adjacent nasal mucosa participates in the inflammatory process, the middle turbinated body becoming enlarged, oedematous, and polypoid. When the oedematous nasal wall and enlarged turbinal come into contact, a condition suggestive of "cleavage" of the turbinal is produced, while, as the result of granulomatous formation, polypi frequently develop.

The subjective symptoms of empyema of the accessory sinuses, so far as chronic purulent disease is concerned, are not particularly striking, but become so when intercurrent attacks of acute inflammation are superadded. The main symptoms are pain or tenderness, either local or referred. In many chronic cases pain is entirely absent, but may become a prominent symptom during attacks of intermittent inflammation. Local tenderness is, however, fairly constant. In maxillary antral disease it is complained of over the corresponding side of the nose and in the infra- and supra-orbital regions; in frontal sinus suppuration over the floor of the sinus under the supra-orbital arch. In ethmoidal and sphenoidal suppuration local pain is, from the situation of the sinuses, of no diagnostic value. Neither is referred pain, although frequently complained of, of any diagnostic value. In antral suppuration it is referred to the side of the nose, the supra-orbital, or the malar region; in frontal sinus suppuration to the glabella and forehead; in ethmoidal suppuration to the top of the head in the middle line; and in sphenoidal suppuration to the top and back of the head, occasionally also to the forehead. It must be borne in mind, however, that much of the pain complained of is frequently due not so much to the fact that accessory suppuration is present, but to the presence of nasal obstruction and pressure effects.

Objective Symptoms.—The main objective indication consists in the presence of a discharge, purulent or muco-purulent, foetid or non-foetid, and in colour varying from a creamy white to an orange yellow. Occasionally it is blood-stained.

Pus coming from the frontal sinus, maxillary antrum, or anterior ethmoidal cells flows, as a rule, towards the anterior nares. Its flow is accelerated by holding the head forwards and downwards between the knees (posture test), especially in the case of antral suppuration.

In antral, frontal, and anterior ethmoidal suppuration it is seen issuing under cover of the middle turbinated body between it and the outer nasal wall.

In order to ascertain the source of the flow the nasal passages should be thoroughly cleansed, and the mucosa rendered less oedematous by the local application of cocaine-adrenalin solution to the mid-meatal region. A careful inspection should then be made under good illumination to ascertain if possible from which sinus the flow is taking place. For this purpose it is at times advisable to insert the blades of Killian's long nasal speculum (Fig. 280) between the middle turbinal and the outer nasal wall. The introduction of small pledgets of cotton wool one after the other as nearly as possible over the ostia of the various sinuses helps at times to determine which sinus is implicated. In most cases, however, other methods of diagnosis have to be adopted, such as transillumination, catheterisation, puncture, and lavage.

In cases of suspected antral suppuration transillumination, although not an absolute test, possesses great value. Introduced originally by Heryng, it consists in the introduction into the mouth of a small 4 to 8 volt electric lamp mounted upon a rectangular stem, the examination being conducted in a perfectly dark room, or under cover of a thick velvet cloth thrown over the heads of both patient and examiner. When in a normal case the light is switched on the two sides of the face will be equally illuminated, the rays of light passing through the bones of the face, the areas of brightest illumination being seen where the bones are thinnest, *e.g.* the floor of the orbit, immediately under the lower eyelid and also over the nasal bones. In addition, both pupils become equally and brilliantly lit up, appearing as bright red discs.

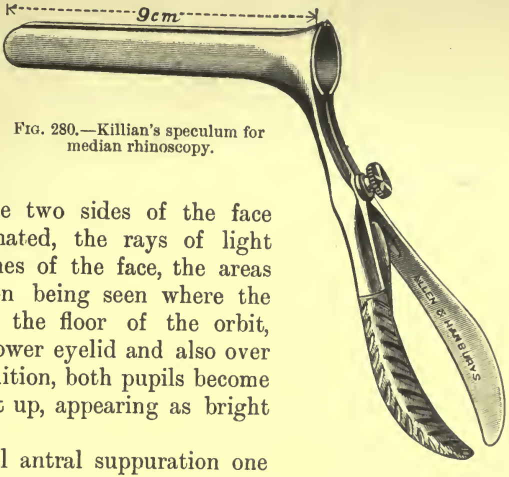

FIG. 280.—Killian's speculum for median rhinoscopy.

In cases of unilateral antral suppuration one side of the face will be lit up, while the other will remain dark and opaque, from the fact that the rays of light are incapable of traversing the thick layer of pus within the cavity.

In addition, the reflection of the retina as seen through the pupil will be apparent upon the sound and absent upon the diseased side, while the patient will be conscious of the light upon the healthy but not upon the affected side.

In bilateral empyemata both sides will be dark and the pupil reflex absent.

The transillumination test, although not absolutely reliable, is of great practical assistance. The presence of very small but healthy antra, or unduly thick upper jaw bones, or the presence of a growth, may give rise to an erroneous diagnosis, or the quantity of pus present may be so small as to permit of the rays of light passing through. The presence of a cyst in the antrum, on the other hand, intensifies the illumination.

A diagnosis of antral suppuration may be made with almost absolute certainty in a case of unilateral nasal suppuration with pus in the middle meatus, whose flow is increased by the posture test, and when transillumination gives a positive result.

A second method of ascertaining the presence of pus within the sinus is irrigation through the natural ostium. It is, however, a method painful to the patient despite the application of cocaine-adrenalin solution, and uncertain from the fact that it is difficult to say whether the cannula has actually reached the cavity or not.

To carry it into effect a long, soft, and curved silver probe is taken, and an effort made under illumination to cause it to enter the ostium. If the surgeon is satisfied that it has gained an entrance it is withdrawn and a suitable cannula bent to the precise curve of the probe. The cannula is then introduced and irrigation effected. A much more satisfactory method, however, is irrigation with a Lichwitz's trochar (Fig. 281). The trochar is introduced obliquely through the outer antral wall under cover of the inferior turbinal or immediately above it through the middle meatus. In both situations the bone is comparatively thin, and the instrument is easily forced through with a boring motion. A syringe is then attached and a stream of sterile warm water injected. If the washings which issue through the *ostium maxillare* contain pus (the nasal chambers having been previously cleansed) the diagnosis is rendered absolutely certain. Where carious teeth exist the roots of the first or second molars may be extracted and a puncture made through the alveolus.

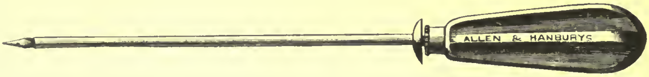

FIG. 281.—Lichtwitz's trochar and cannula.

Sterile water is then injected through the opening thus made, and the washings examined as they flow from the corresponding nasal passage.

In quite recent cases lavage frequently effects a cure. According to the observations of Wyatt Wingrave and J. M. Darling,[1] when microscopic examination of the discharge shows comparatively few lymphocytes to be present, the prospects of accomplishing a cure by lavage are much greater than when large numbers are found.

Treatment.—The various methods in use are :—

1. Irrigation through the ostium maxillare.
2. Puncture and irrigation through the alveolus.
3. Intra-nasal opening of the sinus and subsequent irrigation.
4. Opening through the canine fossa and removal of a portion of the nasal wall of the antrum.

In selecting which particular method to adopt attention should be paid to the cause of the suppuration, whether dental or nasal, its duration, the characteristics of the discharge, and the presence or absence of intra-nasal complications.

Speaking generally 75 per cent of the cases of antral suppuration are of nasal and 25 per cent of dental origin.

Bacteriological and cytological examination of the discharge assists to some extent at least in determining the particular line of treatment to be adopted. When the discharge indicates a catarrhal exudate, free irrigation will most likely effect a cure. When large numbers of lymphocytes are present in association with the *streptococcus* treatment by lavage, either nasal or alveolar, is contra-indicated (A. L. Turner and C. J. Lewis.)[1]

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[1] *Ed. Med. Journal*, Dec. 1909.

1. *Irrigation through the Ostium Maxillare.*—This method is occasionally adopted, but is open to objection on account of the difficulty so often experienced in finding the natural opening and the pain caused by the manipulation of instruments. In addition, the fact that the opening is situated high up upon the nasal wall of the antrum militates against free drainage, and owing to its small size tends to prevent the egress of thick inspissated pus. Moreover, it is frequently necessary in order to obtain access to the opening, to remove the anterior end of the middle turbinated body. In those cases where an accessory ostium maxillare is present the manipulation is, as a rule, somewhat easier. A malleable probe is taken and bent in such a way as to permit of its being passed through the ostium under proper illumination. A suitable cannula is then selected and bent to a similar curve or angle. The cavity is subsequently irrigated through the cannula until the escaping fluid shows no traces of pus. In a certain number of instances (Hajek, Hartmann) this method is successful, but in addition to the disadvantages already spoken of the daily treatment of the case has to be undertaken by the surgeon himself. This method, although possible when the ostium is accessible, has but little practical value.

2. *Puncture and Irrigation through the Alveolus.*—In acute and subacute cases this method may be employed with advantage and success, but as a method of treating chronic suppuration even when due to dental caries, it is not only disappointing but is also non-surgical from the fact that it establishes a communication with a septic cavity—the mouth. In addition the opening is so small that it is not possible to inspect the interior of the cavity or to make local applications to its mucosa. It has, however, the advantage of simplicity and of draining the cavity from its most dependent part. To maintain patency a tube or plug (metal, rubber or vulcanite) should be worn, and irrigation with a rectangular cannula made two or three times daily. Except under quite exceptional circumstances this method should not, in the writer's opinion, be adopted, even if the organisms in the discharge indicate the dental origin of the infection.

3. *Intra-nasal Opening and subsequent Irrigation.*—This method has the advantage of attacking the cavity along the most usual route of infection, of securing drainage almost from the level of its floor, and of incapacitating the patient to the least possible extent. The operation may be performed under local (submucous) or general anaesthesia, with the patient sitting or lying, and with bur, trephine, knife (Donelan), or special forceps (Carwardine). With one or other instrument an opening is made into the sinus at a point about three-quarters of an inch behind the anterior extremity of the inferior turbinal, or after having

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[1] *Ed. Med. Journal*, April 1910.

removed the anterior third of the turbinal by making an opening and enlarging it by the use of larger and larger burs or cutting forceps, the idea being to secure a permanent opening of sufficient size to maintain free drainage (Fig. 283). Irrigation is subsequently effected by passing a Parker's cannula along the inferior meatus and turning it into the antrum.

In many cases this method gives excellent results, and is often worth while trying before resort is had to the more radical operation through the canine fossa.

4. *Opening through the Canine Fossa, Caldwell-Luc Operation.* — This method is indicated in those cases of obstinate suppuration when one or other of the previous methods has been tried and has failed, or in cases where the discharge is peculiarly chronic and foetid, and where there is reason to suspect the presence of polypoid degeneration of the mucosa or caries.

The patient is placed under the influence of a general anaesthetic and all carious teeth are extracted.

The post-nasal space having been plugged with a sponge or Kuhn's per-oral intubation tube having been introduced into the larynx and the mouth packed with gauze, a horizontal incision through the mucous membrane is then made quarter of an inch above the alveolar margin and across the canine fossa. The incision may or may not be carried through the periosteum, the writer's plan being to merely divide the mucosa. A broad rake retractor is then introduced and the loose mucosa drawn upwards. With a gouge an opening is made into the sinus through the canine fossa and rapidly enlarged until capable of admitting the forefinger (Fig. 282). The sinus is then swabbed out and temporarily packed so as to arrest haemorrhage which is frequently very free. A careful inspection of its lining membrane is then made. Oedematous granulation tissue and polypi are removed with ring-knife or sharp spoon, care being taken to preserve the mucosa. The provision of free drainage and the subsequent irrigation of the cavity with antiseptics soon bring about a cessation of discharge, whereas if the mucosa is scraped away healing has to take place by the formation of scar tissue, a long, troublesome, and often unsatisfactory process.

A large counter opening is now made through the outer wall of the nose under cover of the inferior turbinated body with or without removal of a portion or the whole of the turbinal itself (Fig. 283).

To effect this the surgeon introduces his left forefinger into the nasal passage to protect the septum nasi, and then with a sharp spoon or a hand bur makes an opening of the requisite size. The size of opening made varies with individual operators, the writer's practice being to cut away the whole outer nasal wall under cover of the inferior turbinal and the middle third or thereby of the turbinal itself. The antral cavity is then carefully cleansed and packed lightly with a long strip of gauze which is brought out through the corresponding nasal passage. The original incision may or may not be sewn up, the writer preferring to leave it unstitched, the weight of the cheek keeping its edges in accurate apposition.

The gauze packing should be removed at the end of forty-eight hours, and the cavity irrigated with perhydrol solution through a Parker's cannula. The patient is subsequently taught to pass this instrument himself and instructed to make irrigation two or three times daily.

The advantages of the Caldwell-Luc operation are, that it is radical, that it permits of a thorough inspection of the diseased cavity, the ultimate establishment of free intranasal drainage, and the avoidance of a fistulous connection with the buccal cavity.

Anterior Ethmoidal Suppuration.—When a diagnosis of anterior ethmoidal suppuration has been made, operative treatment consists in opening up and draining the infected area, either intra-nasally or by means of an external operation. The latter procedure is seldom necessary except in those cases where a fistula is present or intra-cranial complications are threatened. In mild cases the operation may be done under local anaesthesia with the patient sitting in a chair; in more extensive disease it is, however, preferable to put the patient under a general anaesthetic and to complete the operation at one sitting. After the application of cocaine-adrenalin solution the anterior third of the middle turbinal is cut away with scissors, snare, or forceps. A Hajek's hook (Fig. 284) is then taken and the bony septa of the anterior ethmoidal cells broken down. In more extensive cases, and when treatment by

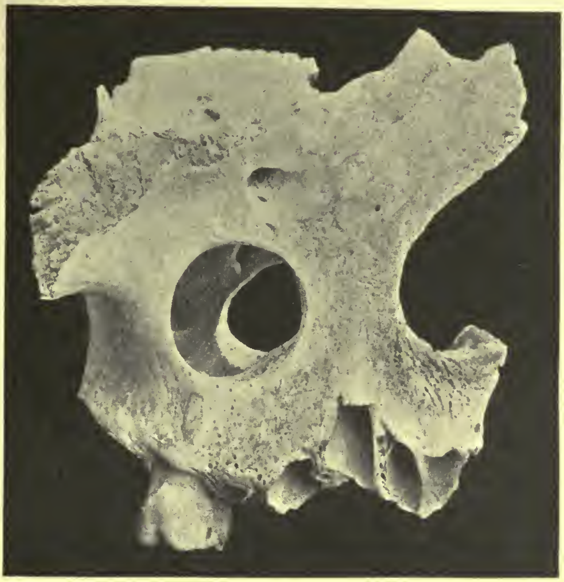

FIG. 282.—Superior maxilla, showing opening in canine fossa for exploration of a maxillary antral empyema. Caldwell-Luc operation.

local manipulation has failed, the patient should be put under the influence of an anaesthetic and the whole infected turbinal area, carious bone, granulation tissue, polypi, etc., scraped away with a ring-knife or large Volkmann's spoon. Subsequent treatment consists in irrigation with alkaline antiseptics. When a fistula exists it is preferable to open the infected area from without. The eyebrow and adjacent skin having been cleansed and painted with iodine-chloroform solution, a curved incision is made from the supra-orbital notch to about half an inch below the inner canthus. The soft tissues are retracted, the fistula sought for and enlarged, and access gained in this way to the infected cells. Manipulation is much facilitated by introducing the forefinger into the nasal passage and using it as a guide upon which to work; also by passing a Kuhn's per-oral intubation tube (Fig. 285) through which the anaesthetic is administered, and packing the nasopharynx and pharynx with gauze. By so doing the anaesthetist does not

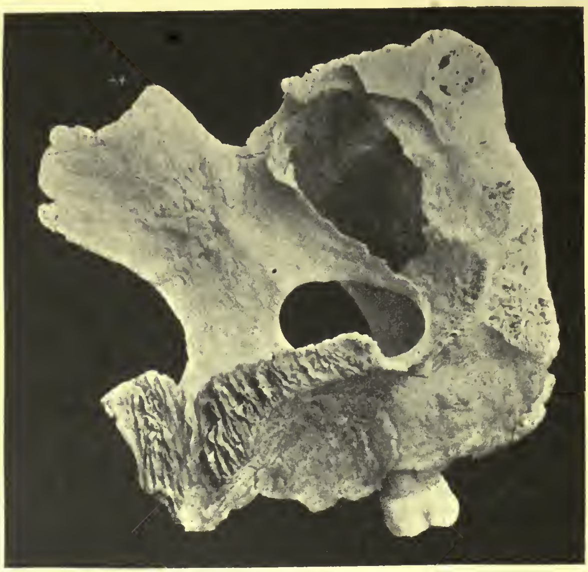

Fig. 283.—Internal aspect of superior maxilla showing opening for intra-nasal drainage of a maxillary antral empyema.

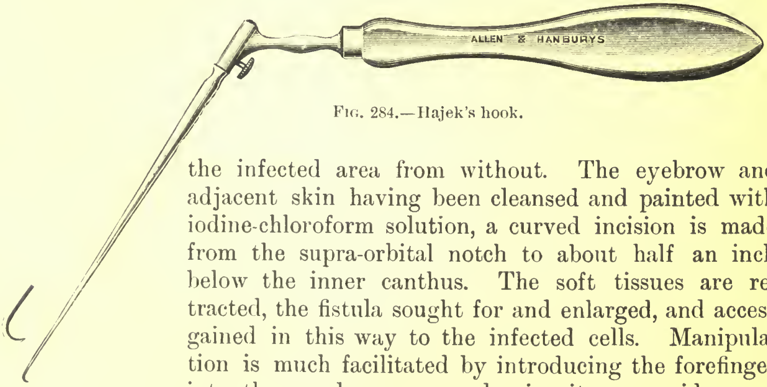

Fig. 284.—Hajek's hook.

interfere with the operator, and the trickling of blood into the pharynx with consequent hawking and coughing is done away with, and all sponging rendered unnecessary.

A large tube, through which daily irrigations are made, is then passed through the external opening and brought out through the corresponding anterior naris. Subsequently a rubber plug may be worn until all discharge has ceased. Suppurative disease of the ethmoidal labyrinth is, owing to the complicated arrangement of its cellular structures, often very difficult to arrest and disappointing in its results.

Frontal Sinus Suppuration.—Should pus still continue to flow from the anterior end of the nasal passage after treatment of the maxillary antrum or anterior ethmoidal cells (or after having eliminated these cavities from participation in the morbid process) the rational deduction is that the flow is taking place from the frontal sinus. In many such cases no symptoms beyond the inconvenience of an intermittent purulent discharge from the nose are complained of; in others, however, there is constant headache or a feeling of weight in the head (generally most marked in the forenoon), which becomes at times so great as to cause complete incapacity. The flow of pus, moreover, induces the formation of granulation tissue or polypi, with resulting nasal stenosis and severe discomfort. The presence of purulent disease in the sinus leads at times to perforation of its walls, pus tracking backwards through its posterior wall into the anterior cranial fossa, or outwards into the cellular tissue of the orbit. In the former case an extra-dural or frontal lobe abscess may result, or the subdural space may become infected with resulting meningitis. The constant inhalation of germ-laden pus is also at times responsible for the production of purulent bronchitis, pneumonia, and suppurative disease of the middle ear.

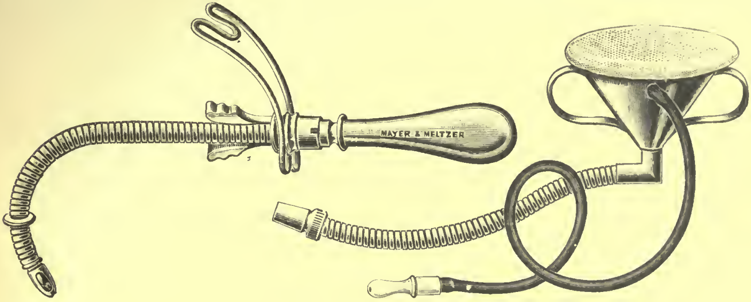

FIG. 285.—Kuhn's per-oral intubation tube.

In the treatment of frontal sinus suppuration, an endeavour should be made in the first instance to effect a cure by one or other method of intra-nasal manipulation. Should this fail, resort may then be had to external operation, an operation, however, by no means devoid of risk, and not always satisfactory in its results.

Intra-nasal methods of treatment consist in (1) lavage of the sinus,

(2) opening and drainage of the sinus, the first step in all cases being to remove the anterior end of the middle turbinal (p. 524) so as to secure free access to the infundibulum.

After an interval of seven to ten days, by which time healing has taken place, a pliable probe is taken, and under illumination is passed with great care and gentleness upwards along the infundibulum and towards the sinus, its movements being watched, if possible, on the fluorescent screen. By carefully curving the probe, it is possible, in a certain number of cases, to reach the cavity of the sinus, the feeling of having reached an empty space being conveyed to the examiner's hand, or the fact of its having reached the sinus being seen upon the screen. Once the proper curve has been found, a cannula (Fig. 286) is taken and correspondingly bent, and kept for the individual patient. Instead of a probe a fine Eustachian catheter may be employed, through which air or fluid may be injected. Its entrance is easily heard through a stethoscope placed on the forehead over the region of the sinus. The greatest care must be taken, as there is always considerable risk of injury to the cribriform plate. This is avoided by keeping well to the outer side of the middle turbinal or its point of attachment. Daily irrigation with antiseptic solutions is then instituted.

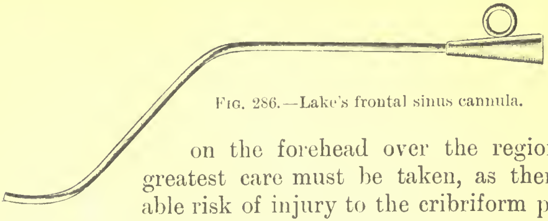

FIG. 286.—Lake's frontal sinus cannula.

The results are, however, far from ideal. The method is not only not free from danger, but is difficult to follow out, and is extremely irksome to the patient. The writer has never yet seen a genuinely chronic case cured by this method. A certain amount of relief is possible, but so soon as treatment is stopped so soon do symptoms recur.

As a means of facilitating drainage, Dundas Grant[1] has suggested dilatation of the infundibulum with graduated metal bougies curved on the principle of Hartmann's frontal sinus cannula, and graduated in millimetres.

The removal of the anterior third of the middle turbinal gives at times relief from headache and nasal obstruction, and although it does not cure the disease, it at least mitigates symptoms and facilitates drainage by exposing the hiatus semilunaris, into which three sinuses open.

External Operations.—External operation should only be undertaken in those cases in which relief by intra-nasal methods has not been secured, and when symptoms, *e.g.* headache, mental lethargy, foetid discharge, etc., are such as to seriously interfere with the patient's general health. The operation is not only difficult to perform, but is also by no means free from danger, many fatal cases having been recorded. The after-treatment is also troublesome and necessitates long attendance, while considerable deformity often follows ultimate cicatrisation.

In every case previous to the performance of an external operation, it has been the writer's practice to have an x-ray photo made (anteroposterior and lateral views) so as to define the configuration and size of the sinus. The various methods of dealing with the sinus are (1) simple opening and drainage into the nose; (2) opening and curetting of the lining membrane followed by drainage into the nose or packing; (3) obliteration of the sinus.

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[1] *Brit. Med. Journ.* 26th September, 1908.

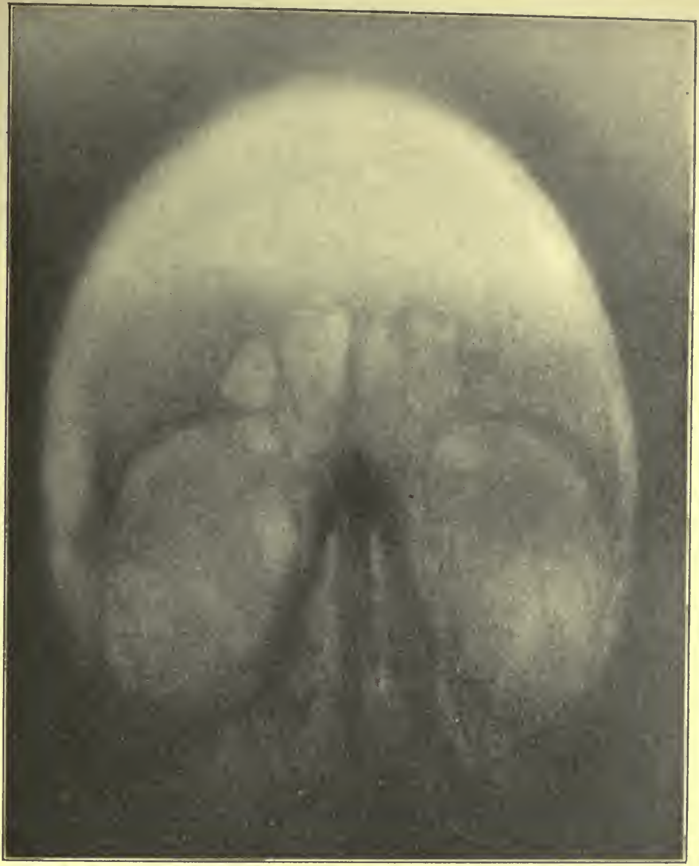

Fig. 287.—X-ray photograph of normal frontal sinuses showing the configuration and size of the cavities.

Opening of the Sinus and Provision of Intra-nasal Drainage.—The skin of the eyebrow and adjacent parts is cleansed, and iodine-chloroform solution applied with a brush. The eyebrow itself should be shaved. The patient is placed under a general anaesthetic, and the post-nasal space packed with a sponge, or Kuhn's per-oral tube introduced, and the mouth and posterior nares packed with gauze. An incision is then made along the inner third of the eyebrow on to the lateral wall of the nose. All bleeding points, of which there are many, are picked up and clamped, and the periosteum pushed backwards. A small opening is made with a gouge immediately above the inner canthus and below the orbital ridge, because if the sinus exists at all it will be found in this situation (Logan Turner). The opening is enlarged with bone forceps (Citelli's) so as to expose the lining of the sinus, which presents a dark-bluish colour. This is then opened with a knife or probe. If pus is present, it, as a rule, wells up, if not, a bent probe should be introduced into the sinus, and the cavity explored so as to determine its dimensions, the presence of polypi, etc. In cases where no pus is found and the mucosa appears healthy, the soft parts should be brought together again and stitches inserted. If, on the other hand pus is present, the incision should be enlarged and more bone removed, so as to obtain a good view of the interior of the sinus.

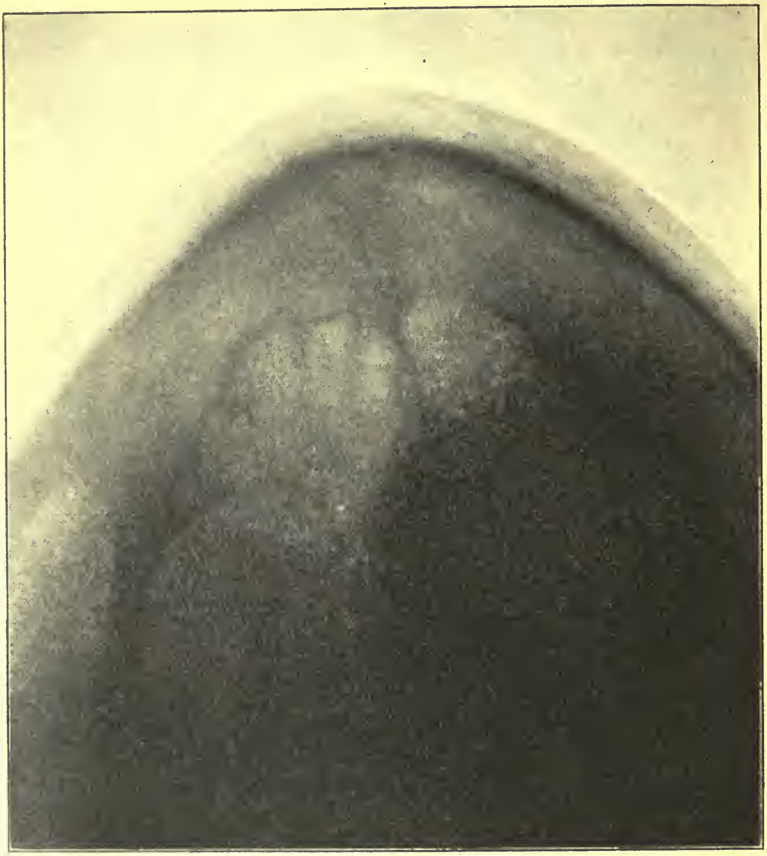

FIG. 288.—X-ray photograph of a case of left-sided suppurative frontal sinusitis showing marked opacity.

The less the mucosa is interfered with the better, but when granular or polypoid, it should be gently but thoroughly curetted, healthy areas being left severely alone. A probe should then be introduced into the infundibulum, and the passage enlarged sufficiently to accommodate a good-sized perforated rubber drainage tube, which should be stitched to the margin of the skin incision. Daily irrigation of the cavity should then be practised for a week or ten days, after which a rubber plug or silver drain (Lack) may be inserted. In simple cases this method of opening and draining the sinus may prove sufficient.

When the mucosa presents all the appearances of chronic purulent inflammation — thickening, granularity or formation of polypi — the cavity may be treated by drainage with or without obliteration.

Drainage without Obliteration.—The opening into the floor of the sinus, already made for exploratory purposes, is enlarged by removal of more bone. In doing so it is frequently necessary to dislocate the attachment of the pulley of the superior oblique muscle (with the production of temporary diplopia). Sufficient bone from the floor of the sinus and from the inner wall of the orbit is cut away to expose the infundibulum, and to enable the operator to establish communication with the nose. All adjacent (and probably infected) anterior ethmoidal and fronto-ethmoidal cells are then freely removed with the curette, its movements being regulated by the finger introduced into the nose.

The walls of the cavity are then swabbed with a strong antiseptic solution, and a large drainage tube inserted and brought through the nose. The skin incision is then sutured, and the usual dressings applied.

Obliteration of the Cavity (Killian).—In many cases of chronic disease this method is undoubtedly the most effective, and from the point of view of healing frequently the most rapid.

The indications for its performance, according to Killian, are:

1. Failure of other operations.
2. Presence of fistula or abscess, or indications of necrosis.
3. Symptoms of intra-cranial complications.
4. The presence of pain, fever, foetid discharge.
5. Persistent headache (mainly around the eye), not relieved by intranasal treatment.
6. When the discharge remains foul in spite of persistent irrigation.
7. When recurrent polypi are the result of fronto-ethmoidal suppuration.
8. When a simple purulent discharge is not relieved by careful intranasal treatment, and the patient desires permanent relief by radical operation.

The operation consists in the complete removal of the anterior and inferior walls of the sinus, with or without the preservation of a bridge of bone, the supra-orbital arch. The preservation of the "bridge" is, from a cosmetic point of view, undoubtedly desirable, but tends to retard recovery.

Operation without Preservation of a "Bridge."—The incision is made down to the bone along the whole length of the eyebrow, and on to the lateral wall of the nose (Fig. 289). The soft parts are then retracted, and the whole of the anterior and inferior walls of the sinus removed with gouge and cutting forceps. The mucous membrane of the sinus is then entirely scraped out, the infundibulum enlarged, and all infected fronto-ethmoidal and anterior ethmoidal cells scraped away. A large drainage tube is then inserted, stitched to the inner end of the skin incision, and brought out through the nose. The soft parts are then brought together with stitches, replaced, and pressed down upon the underlying bone by dressings. The drainage tube is left *in situ* for the first week or so, and then removed.

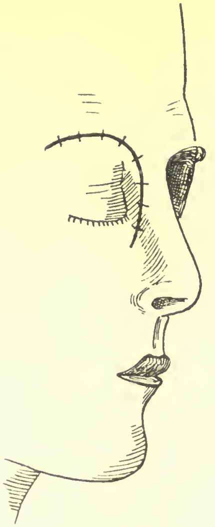

FIG. 289.—Killian's operation. Line of incision—the cross lines indicate slight scratches to secure ultimate accurate apposition of parts.

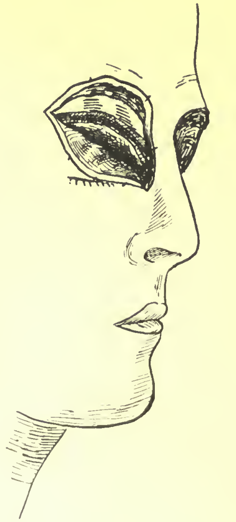

FIG. 290.—Frontal sinus operation (Killian) showing bridge of bone covered by periosteum.

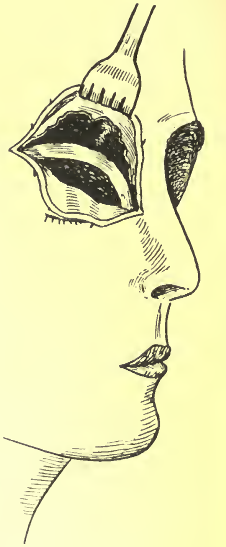

FIG. 291.—Frontal sinus operation (Killian) completed, showing preservation of "bridge."

Operation with Preservation of the "Bridge."—The preliminary incision is made through skin, subcutaneous tissue, and underlying muscular tissue, and the periosteum covering the supra-orbital arch exposed. Two incisions parallel to one another and including the breadth of the "bridge," are then made through the periosteum and down to the bone. The soft tissues above and below the bridge are then pushed aside with a raspatory, so as to freely expose the anterior and inferior bony walls of the sinus, which are then removed with gouge and forceps (Fig. 291). The diseased membrane lining the sinus is then entirely removed and the fronto-ethmoidal and anterior ethmoidal cells curetted.

In doing so, the *lamina papyracea* should be removed as far backwards as it corresponds with the limits of the sinus. During this step in the operation the orbital contents should be carefully protected by a pad of wet gauze, and drawn aside with Killian's retractor. The capsule of the orbital contents may or may not be incised. If incised, the object is to allow of the orbital fat extruding itself, and so of assisting in the obliteration of the sinus.

A large drainage tube is then inserted through the infundibulum, or the cavity may be packed with gauze, its end being brought out at the inner extremity of the skin incision. The edges of the skin incision are then united with sutures. If the sinus be packed the packing should be changed every second or third day; if a drainage tube is inserted, daily irrigation should be made.

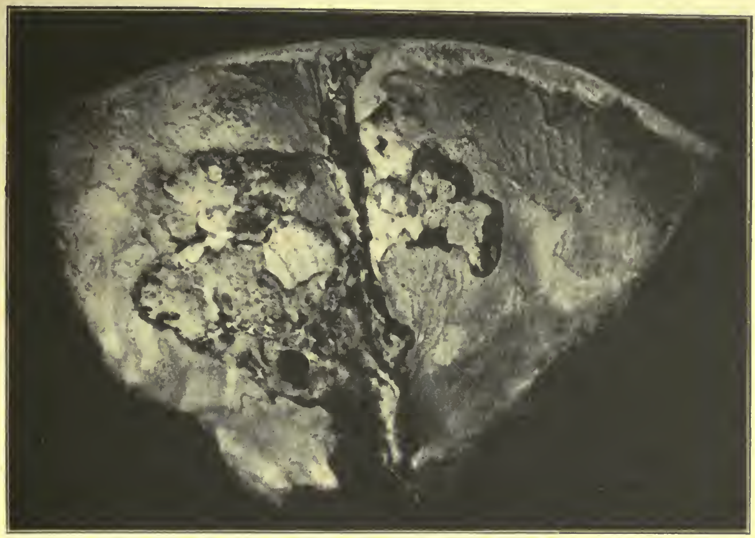

FIG. 292.—Septic osteomyelitis of frontal bone (inner surface) secondary to frontal lobe and extra-dural abscess, the result of chronic suppurative fronto-ethmoiditis.

The results of this last-named method of operation (Killian) are in the main good, although the practical difficulties of securing obliteration of the cavity are considerable, and the after-treatment frequently prolonged.

The dangers and complications to be anticipated and warned against are (1) septic meningitis, (2) osteitis, (3) septic cellulitis, (4) permanent diplopia.

Fatal results have been recorded by several observers, H. Tilley,[1] W. Milligan,[2] L. Lack,[3] and A. L. Turner.[4]

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[1] *Lancet*, xix., 1899, p. 534.; *Ed. Med. Journal*, March 1905.

[2] *Brit. Med. Journal*, 28th January 1905.

[3] *Ed. Med. Journal*, 1901.

[4] *Ibid.* March 1905.

If, however, the inner end of the wound be kept open by the introduction of a tube or strip of packing, complications are very unlikely to occur. Septic orbital cellulitis is an uncommon complication, and may be avoided by strict attention to detail and by provision of free intranasal drainage. Diplopia, which at times lasts for a few weeks, is rarely permanent, and may be avoided by careful reposition of the pulley, or by avoiding detachment of the pulley.

Osteoplastic resection of the anterior wall of the sinus has been suggested and practised by Küster, Jansen, Brieger, and Beck.[1]

Suppurative Disease of the Posterior Ethmoidal Cells and Sphenoidal Sinuses.—The symptoms are the presence of pain referred to the occiput, the appearance of a purulent discharge, as seen with the post-nasal mirror, flowing over the posterior ends of the superior and middle turbinated bodies, and the occasional presence of a contracted field of vision, hemianopsia, with indications of pressure upon the optic chiasma.

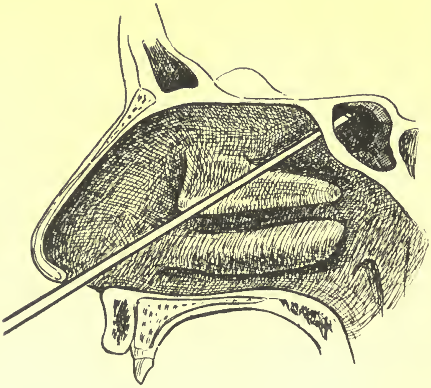

Fig. 293.—Cannula passed through the ostium sphenoidale, showing the diagonal direction of the cannula across the middle turbinated body.

To remove infected *posterior ethmoidal cells*, the whole of the middle turbinated body should first be amputated, and the walls of the cells broken down with Hajek's hook or cutting forceps (Watson Williams).

The *sphenoidal sinus* varies much in size. In many instances it is quite small, and lies above the main body of the sphenoid; in others it is very large, and extends outwards into its wings. The thickness of its walls varies greatly. Its outer wall, often very thin, is in close relationship with the vessels and nerves passing through the spheno-maxillary fissure, while its upper wall is in close proximity to the *sella turcica.*

Its anterior wall varies in thickness but can readily be approached after removal of the middle turbinal. Material assistance as to its size and position is frequently afforded by means of an *x*-ray photo.

To wash out the sinus a long cannula is taken (Fig. 293) and passed diagonally across the middle turbinal. The ostium is then carefully sought for. In cases of difficulty the nasal passage may be dilated (after free cocainisation) by means of Killian's long nasal speculum introduced between the middle turbinal and the septum, and its blades then separated. The anterior wall is, as a rule, readily seen with pus at times oozing through the ostium. The cannula is then introduced and lavage performed. To open the sinus Hajek's hook is introduced through the ostium and its anterior wall pulled away piecemeal, or a special sphenoidal punch forceps may be inserted and its anterior wall clipped away. Great care should be taken, otherwise important structures in the immediate neighbourhood may be injured. Post-operative haemorrhage has frequently been recorded, but has not, so far, occurred in the writer's experience. The provision of free drainage is followed by relief of symptoms, aural, ocular, and cranial, and as a rule by cessation of discharge.

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[1] *Journ. Amer. Med. Association*, 8th August 1908.

In those cases in which multiple sinusitis exists, and when it is desirable to open and drain all the infected cavities from the front, Watson William's osteoplastic operation[1] may be performed with advantage.

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[1] *Brit. Med. Journal*, 26th September 1908.

INDEX

Abscess, Bezold's mastoid, 342
  of the brain, 389
  cerebellar, 408
  epitympanic, 212
  extra-dural, 372
  of nasal septum, 546
  perisinous, 420
  retropharyngeal, 315
  temporo-sphenoidal, 400
Accessory auricle, 67
  nasal sinuses, 568
Acid-fast bacteria, 251
  epithelium, 247
Acoumeter, 30
Acoumetric formula, 38
Acquired deaf mutism, 507
Acute catarrhal rhinitis, 515
  primary inflammation of mastoid cells, 308
  purulent inflammation of mastoid cells, 311
    of middle ear, 198
  purulent rhinitis, 519
  suppurative endomastoiditis, operation for, 316
Adenoid vegetations of nasopharynx, 551
  operations, haemorrhage in, 556
Adenoids, removal of, 554
Adhesions, intranasal, 539
Aditus ad antrum, 154
Aeronauts, aural affections in, 19
After-treatment of radical mastoid operation, 333
Aids to hearing, 242
Alar collapse, 532
Alveolar drainage of maxillary antrum, 573
Anaemia of labyrinth, 456
Anaesthesia of auricle, 92
  local, 55
Anaesthetics in tonsil and adenoid operations, 566
Angioma of auricle, 55, 80
  nasal, 536
Angular forceps, Politzer, 27
Annulus tendinosus, 173
Anosmia, 404
Anterior ethmoidal suppuration, 575
  rhinoscopy, 60
  turbinectomy, 524
Antigen, 464
Antro-tympanic cavity, 163
  cavity, communications of, 163
Aphasia, auditory, 497
Aprosexia, 57, 177
Aqueductus Fallopii, 152
  cochleae, 2, 436
  vestibuli, 2, 434, 436
Army and navy, requirements of, 514
Arterial supply of tympanic membrane, 151
Arteries of auricle, 6
  of external meatus, 8
Artificial perforation of membrana tympani, 195
  tampons, 241, 242
Asch's operation, 544
Atrophic rhinitis, 526
"Attic" punch forceps, 217
Audiphone of Rhodes, 243
Auditory aphasia, 497
  concussion, 505
  hallucinations, 503
    meatus, 7
    nerves, division of, 478
    spontaneous haemorrhage from, 132
    vicarious haemorrhage from, 132
  sense-epithelium, 445
  syncytium, 446
Aural disease and life insurance, 511
  mirror, Botey's, 238
  polypi, 263
  probe, 27
  snare, 271
  specula, 24
  syringe, 27
Auricle, accessory, 67
  anaesthesia of, 92
  anatomy of, 5
  angioma of, 80
  cartilage of, 6
  cysts of, 77
  dermatitis of, 89
  dermoid cyst of auricle, 77
  eczema of, 93
  erysipelas of 89
  fibroma of, 79
  furuncular inflammation of, 76
  gouty deposits in, 87
  gumma of, 108

Auricle, haematoma of, 108
  herpes of, 98
  herpes gangrenosus hystericus of, 100
  histology of, 8
  hyperaemia of, 88
  hyperaesthesia of, 92
  injuries of, 73
  keloid of, 79
  lupus of, 100
    hypertrophicus of, 102
    erythematosus of, 102
  malformations of, 66
  malignant disease of, 83
  motor neuroses of, 364
  muscles of, 6
  noma of, 91
  ossification of, 77
  othaematomata of, 108
  outstanding, 70
  papilloma of, 79
  perichondritis of, 111
  physiology of, 13
  rodent ulceration of, 84
  rudimentary, 67
  sarcoma of, 86
  sebaceous cyst of auricle, 77
  serous cyst of, 78
  supernumerary, 69
  syphilis of, 105
  traumatic deformities of, 67
  vessels of, 6
Auscultation tube, 43
Autophony, 203

Baber's Eustachian catheter, 50
Babinski's sign, 403
Bacillus of influenza, 258
  proteus vulgaris, 257
  septus of Cautley, 373
Bacteria, acid-fast, 251
  in chronic middle-ear discharges, 224
Bacteriology of ear discharges, 244
  of extra-dural abscess, 273
Ballance's operation, 235
  flap, 236
Bárány's noise apparatus, 38
Bezold's mastoid abscess, 314, 342
  "symptom triad," 471
Bier's induced hyperaemia, 207
Bing's test, 37
Blake's blood-clot dressing, 320
Bleeding polypus of septum, 536
Blood count, 262
  clot dressing, Blake, 320
Bone hooks, Krause's, 405
Bonnafont's method of inflation, 45
Botey's aural mirror, 238
  operation (labyrinth), 490
Bougie, use of in stricture of Eustachian tube, 185
Bourguet's facial protector, 491
Brain abscess, 389
Brain, operative opening of, 405
  percussion of, 401
  puncture of, 406
  symptoms of, 400
Broca's convolution, 402
Brühl's plastic operation, 332
Bulb of jugular vein, thrombosis of, 430
  method of opening, 431
Bulla ethmoidalis, 61

Caisson workers, aural affections in, 19
Calcareous degeneration of membrana tympani, 189
Caldwell-Luc operation, 574
Calmette's ophthalmic test, 295
Caloric tests (labyrinth), 452
Canalis reuniens, 440
  utriculo-saccularis, 437
Cannula, "attic," Milligan's, 215
Capsulitis labyrinthi, 465
Caries of external auditory meatus, 145
  of ossicula auditus, 216
Carotid artery, erosion of, 303
Cartilaginous meatus, 7
  portion of Eustachian tube, 155
Caseous rhinitis, 531
Catheterisation of Eustachian tube, methods of, 44
    technique of, 45
  from opposite nasal passage, 49
  mistakes in, 50
  from the mouth, 50
Catheters, Baber's, 50
  Eustachian, 44
Causes of ear disease, 18
Cavum hypo-tympanicum, 328
Cerebellar abscess, 408
    operative opening of, 416
    respiratory paralysis in, 417
    spontaneous evacuation of, 415
    symptoms of, 411
  decompression, 382
  tumours, 500
Cerebello-pontine tumours, 501
Cerebral cortex, tumours of, 499
  embolism, 496
  haemorrhage, 496
  infection, paths of, 408
  thrombosis, 496
  vomiting, 401
Cerebro-spinal fluid, 395
Cerumen in external auditory canal, 121
  deficient secretion of, 125
Ceruminous glands, 8
Cervical branchial fistula, 81
Cheyne-Stokes respiration, 410
Cholesteatoma, 279
  capsule and lining of, 280
  foetal inclusions, 279
  formation of, 282
  in epitympanic recess, 282
  in middle-ear cleft, 284

Cholesteatoma in external attic, 284
  in temporal bone, 283
  morbid anatomy of, 283
  mycelia and spores in, 283
  of developmental origin, 282
  pathogenesis of, 282
  pathology of, 280
  primary, 280
  recurrence of, 286
  retention of matrix, 286
  secondary, 284
  spontaneous extrusion of, 286
Chondromata, 82
Chondromyxoma of auricle, 82
Chorda tympani nerve, course of, 163
  injury to, 226
Chronic catarrh of Eustachian tube, 183
  catarrhal rhinitis, 521
  eczema of external ear, 94
  purulent inflammation of mastoid cells, 321
   of middle ear, 221
  suppurative otitis media, ocular signs in, 227
Cicatrices of membrana tympani, 238
  adherent, 238
Cisterna-subarachnoid, 383
Clar's photophore, 23
Clinical divisions of membrana tympani, 29
Clostridia, 252
Cochlea, anatomy of, 434
  extirpation of, 479
  modiolus of, 434
Cochlear and vestibular nerves, distribution of, 444
  tube, 439
Coggin's test, 512
Collapse of alae nasi, 532
Compressed air in treatment of adhesive processes, 193
Condylomata of external ear, 105
Congenital deaf-mutism, 507
  malformations of ear, 66
  occlusion of posterior choanae, 548
Corti, anatomy of organ of, 442
  rods of, 443
Cortical centre of hearing, 403
  mastoid operation, 318
Crista maxillaris, 543
  vestibuli, 434
Cupric electrolysis, 529
Cushing's "intermuscular" decompression operation, 383
Cyst formation in auricle, 77
  in aural polypi, 265
Cytology of ear discharges, 244

Deaf-mutism, 507
  acquired and congenital, 507
Deafness, apoplectic form of, 458
  hysterical, 502
  leukaemic, 460
Deafness, simulated, 512
Decompression operation, 382
Decussation of motor fibres, 402
Deiter's nucleus, lesions of, 414
Delstanche's masseur, 54
  ring knife, 219
Dermatitis of auricle, 89
Dermoid cyst of auricle, 77
Deviations of septum nasi, 540
Diabetes, deafness in, 20
Diabetic mastoiditis, 343
Digital exploration of post-nasal space, 65
Diphtheria of middle ear, 301
  nasal, 520
Diplacusis, 55
  dysharmonica, 55
  echoica, 55
Diplococcus catarrhalis, 254
  meningitidis intracellularis, 387
Discharges from ear, pathology of, 244
Diseases of labyrinth, 451
  of mastoid process, 305
  of nose and nasopharynx, 515
Disdiadokokinesis, 500
Dislocation of triangular cartilage, 540
Disseminated sclerosis, 501
Division of auditory nerve, 478
Division of posterior fold of membrana tympani, 196
Dokokinesia, 500
Dorello's space, 375
Double vestibulotomy, 494
Dry perforation, treatment of, 239
  treatment of middle-ear suppuration, 236
Ductus cochlearis, 440
  endolymphaticus, 437
Dundas Grant's Eustachian self-inflator, 52
  furuncle knife, 128
  mastoid hook, 319
Dura mater, diseases of sinuses, 366

Ear cleft, foreign bodies in, 114
  cough, 26
  discharges, cytology of, 244
   bacteriology of, 244
Eczema of auricle, 93
Effects of inflation upon audition, 49
Embolism, cerebral, 496
Eminentia papillaris, 49
Empyema of fronto-ethmoidal sinuses, 577
  of antrum of Highmore, 571
  of saccus endolymphaticus, 369
Encephaloscope, Whiting, 407
Enchondroma, nasal, 538
Endarteritis obliterans, 461
Endolymph, 433
Endo-mastoiditis, acute suppurative, operation for, 316
Endothelioma, 86
Epidemic cerebro-spinal meningitis, 386
Epidural abscess, 372
Epitympanic suppuration, 212

Erhard's test, 513
Erysipelas of auricle, 89
Erythroblasts, 249
Eustachian tube, arteries of, 162
  catarrhal inflammation of, 183
  catheterisation of, 44
  pharyngeal orifice of, 155
  purulent inflammation of, 184
  self-inflator, Grant's, 52
  stricture of, 185
  tympanic orifice of, 155
Examination of ear, 22
  of external auditory meatus and membrana tympani, 28
  of middle ear, 41
  of nasal cavities, 58
  of naso-pharynx, 58
  of patient, 22
  of pharynx, 58
Exostosis, cancellous, 138
  ivory, 138
External attic, suppuration of, 213
  auditory canal, 7
    atresia of, 143
    cerumen in, 122
  auditory meatus, cario-necrosis of, 145
    foreign bodies in, 114
    fracture of walls of, 73
    fungi in, 135
    furunculosis of, 126
    osseous tumours in, 138
    stricture of, 144
  ear, injuries of, 73
    medico-legal importance of injury to, 75
    new formations, 78
  rectus muscle, paralysis of, 374
Extirpation of cochlea, 479
  of cochlea, Lake's incision, 480
Extra-cerebellar tumours, 500
Extraction of stapes, 474
Extra-dural abscess, bacteriology of, 373

Facial nerve, 327, 352
  injuries of, 353
Facial paralysis, 203, 290, 312, 352
  bilateral, 356
  treatment of, 356
Facio-hypoglossal anastomosis, 359
Facio-spinal anastomosis, 358
Fallopian aqueduct, 152
Fatal haemorrhage from middle ear, 303
Fenestra cochleae, 434
  ovalis, 468
  tympani, 435
  vestibuli, 434, 435
Fibrolysin, injection of, 192
Fistel-symptom (labyrinth), 487
Fistula auris congenita, 71
Fistula of mastoid process, 315
Foramen centrale, 435
  singulare, 435, 445
Foreign bodies in external auditory meatus, 115
  bodies in middle-ear cleft, 119
Fossula cochleae, 435
  rotunda, 29, 326, 435
Fourth ventricle, drainage of, 382
Fovea elliptica, 434
  spherica, 434
Fracture of walls of meatus, 170
Frontal sinus, suppuration, 577
  operations upon, 581
Frost bite, 76
Fungi of external auditory canal, 135

Galton-Edelmann whistle, 34
Galton's whistle, 34
Ganglion spirale, 444
Gellé's test, 36
Giant cells, 249
Gleason's operation, 541
Gonococcus, 255
Gouty deposits in auricle, 87
Granuloma, non-specific, 272
  syphilitic, 276
Granulomata, lupus granuloma, 275
  non-specific type, 272
  syphilitic, 275
  tuberculoma, 274
  varieties of, 272
Griesinger's symptom, 424
Grimmer's intraperitoneal inoculation, 297
Grünert's operation, 430
Gumma of auricle, 108
Guye's aprosexia, 57, 177

Haematology, 395
  in aural disease, 261
Haematoma auris, 108
  of nasal septum, 546
Haemorrhage from the ear, traumatic fatal, 303
  in adenoid operations, 556
  in tonsil operations, 565
  into labyrinth, 457
Hair cells of Corti's organ, 443
Hallucinations, auditory, 503
Hay's pharyngoscope, 64
Hearing power, tests for, 30
Helicotrema, 439
Helix, microscopic structure of, 6
Henle's spine, 317, 324
Herpes of auricle, 98
  gangrenosus, hystericus of, 100
Hiatus subarcuatus, 12
  semilunaris, 60
Hinsberg's operation (labyrinth), 490
Horsley's pus-seeker, 406
  wax, 405
Hydraemia of labyrinth, 455
Hyperacusis, 55
  hysterical, 502
Hyperaemia of auricle, 88

- Hyperaemia of labyrinth, 454
  - of promontory, 470
- Hyperaesthesia of auricle, 92
  - acustica, 502
- Hypertrophy of nasal mucosa, 533
  - of tonsils, 558
- Hysterical deafness, 502
  - hyperacusis, 502

- Incisurae Santorini, 3
- Incus, 159
  - anatomy of, 159
  - processus brevis, 159
    - longus, 159
      - indications for removal of, 217
  - removal of, Ludewig's operation, 219
    - Zeroni's operation, 219
- Induced hyperaemia, 207
- Infantile type of temporal bone, 165, 312, 325
- Infant's ear, 10
- Inferior turbinals, removal of, 524
  - vestibulotomy, 493
- Inflammation of labyrinth, 476
  - of mastoid periosteum, 305
- Inflation of ear, effects upon audition, 49
  - Bonnafont's method, 45
  - Lincke's method, 46
  - Loewenberg's method, 46
  - method of, 43
  - Politzer's method, 42
- Influenza, ear affections in, 301
  - otitis media in, 301
- Injection of fluids into middle ear, 51
- Injuries of external ear, 73
  - of middle ear, 148
- Inoculation test for tubercle, 297
- Insanity, 503
- Insects in auditory meatus, 118
- Internal auditory meatus, 435
  - ear, injuries of, 505
  - sequestra from, 483
- Intra-auricular transplantation of skin grafts, 341
- Intracerebellar tumours, 501
- Intracranial complications of middle-ear disease, 366
- Intradural abscess, 371
- Intranasal adhesions, 539
  - opening of maxillary antrum, 573
  - obstruction, 532
- Intrapontine vascular lesions, 498
- Intratympanic injections, 53
- Irrigation through ostium maxillare, 573
- Isthmus of Eustachian tube, 155
  - of osseous meatus, 7
- Iter ad antrum, 311, 325
  - chordae anterius, 149

- Jacobson's nerve, 162
- Jansen's operation (labyrinth), 490
- Jugular bulb, 421
- Jugular bulb, its relation to tympanum, 421
    - wounding of, during paracentesis, 419
  - sinus, 421
  - vein, ligature of, 428
    - thrombosis of, 421

- Kassowitzsch's solution, 472
- Keloid of auricle, 79
- Keratosis obturans, 124
- Killian's frontal sinus operation, 542
- König's rods, 34
  - test, 34
- Körner's flap, 329, 330
- Krause's bone hooks, 405
- Krieg-Bonninghau's operation, 545
- Küster-Bergmann operation, 323

- Labyrinth, anaemia of, 456
  - blood-vessels of, 436
  - diseases of, 451
  - concussion of, 505
  - hydraemia of, 455
  - hyperaemia of, 454
  - inflammation of, 476
  - in leukaemia, 460
  - necrosis of, 482
  - non-suppurative affections of, 478
  - suppurative disease of, 480
- Labyrinthine haemorrhage, 457
  - syphilis, 460
- Lagena, 440
- Lake's incision for extirpation of cochlea, 480
- Lamina papyracea, 583
  - spiralis ossea et membranacea, 434
- Landmarks of membrana tympani, 29
- Latent mastoiditis, 341
- Lateral sinus, 367
- Leiter's coil apparatus, 307, 316
- Leptomeningitis, 376
- Leucocytes, 248
- Leukaemic deafness, 460
- Life insurance and aural disease, 511
- Ligamentum spirale, 439
- Ligature of jugular vein, 428
- Light-reflex, 29
- Limbus, 440
- Lincke's method of inflation, 47
- Lister's ear hook, 118
- Local anaesthesia, 55
  - in removal of tonsils, 564
- Locomotor ataxia, disturbances of hearing in, 501
- Loewenberg's agglutinative method, 116
  - method of inflation, 47
- Lucae's pressure probe, 54
- Ludewig's hook, 220
- Lumbar puncture, 385
- Lupus of auricle, 100
  - erythematosus of auricle, 103
  - granuloma, 275
  - hypertrophicus of auricle, 102

Lupus vulgaris, 100
Lymphatics of auricle and external auditory meatus, 6
Lymphocytes, 248
Lysin, 464

Macewen's supra-meatal triangle, 317, 324
Macrotia, 70
Macula acustica, 438
Magnifying aural speculum, 25
Malignant disease of auricle, 83
  of middle-ear cleft, 348
Malleus, 158
  removal of, 218
Manometer, 49
Manubrium mallei, 29
Massage of ossicular chain, 53
Mastoid antrum, development of, 154
    landmarks for, 324
  cells, acute primary inflammation of, 308
    acute purulent inflammation of, 311
    acute secondary inflammation of, 311
    chronic purulent inflammation of, and indications for opening up, 321
  hook, Dundas Grant's, 319
  operation, after-treatment of, 333
  osteo-sclerosis of, 166
  periostitis, Wilde's incision in, 317
  primary acute periostitis of, 305
  process, diseases of, 305
  retractor, self-retaining, 317, 318
  secondary periostitis of, 305
Mastoiditis, Bezold's, 342
  diabetic, 343
  latent, 341
Maxillary antrum, alveolar drainage of, 573
  Caldwell-Luc operation, 574
  intranasal opening of, 573
Measles, ear affections in, 300
Meatus, abnormalities of, 67
  and membrana tympani, 29
Median rhinoscopy, 570
Medico-legal importance of injuries of ear, 75
Membrana basilaris, 439, 441
  flaccida Shrapnelli, 29, 158
    perforation of, 212
    tectoria, 17, 441
  tympani, artificial perforation of, 195
    division of posterior fold, 196
    inflammatory affections of, 167
    landmarks, 29
    perforation of, in otitis media, 204
    rupture of, 172
      from basal fracture, 170
      in caisson workers, 170
      during inflation, 171
Membranous labyrinth, 437
  rhinitis, 520
    traumatic, 520
Menière's disease, 438, 458
  symptoms and pseudo-symptoms, 458
Meningitis, 376, 498
  epidemic cerebro-spinal, 386
  purulenta, 376
  serosa, 384
Meningococcus, 255
Microtia, 69
Middle-ear cleft, 148
  malignant disease of, 348
Middle-ear disease, intracranial complications in, 366
  in syphilis, 350
Middle ear, sarcoma of, 349
  tuberculous disease of, 287
  turbinal, operation on, 525
Military service and aural affections, 514
Milligan's aural probe, 27
  intratympanic syringe, 215
  operation (labyrinth), 491
    (tonsils), 562
  plastic operation, 332
  self-retaining mastoid retractor, 317
Mirrors, aural, 24
Mistakes in catheterisation, 50
Mobilisation of stapes, 473
Modiolus of cochlea, 434
Morro's tuberculin ointment, 295
Mosetig-Moorhof plastic operation, 345
Motor fibres, decussation of, 402
  neuroses of auricle, 364
    of tympanum, 364
Moure's operation, 545
Mumps and aural disease, 480
Mycosis of external auditory canal, 135
Myelocytes, 249
Myringitis, acute, 167
  chronic, 169

Nasal angioma, 536
  cavity, examination of, 60
  enchondroma, 538
  fibroma, 536
  mucosa, hypertrophy of, 533
  osteoma, 538
  papilloma, 535
  polypus, 533
  septum, abscess of, 546
    haematoma of, 546
Naso-antral polypus, 557
Nasopharyngeal adenoids, 551
  catarrh, 549
Nasopharynx, digital examination of, 65
  tumours of, 556
Navy and Army, requirements of, 514
Necrosis of external auditory meatus, 145
  of labyrinth, 483
  of ossicles, 217
  of temporal bone, 145
Nerves of auricle and auditory meatus, 6
  of tympanic cavity, 163
Neumann's operation (labyrinth), 490

Neumann's injection method, 56
Neurasthenia, ear affections in, 503
Noise apparatus, Bárány, 38
Noma of auricle, 91
Nose and nasopharynx, diseases of, 515
Notch of Rivini, 151
Nystagmus, 452, 459
  cerebellar, 414
  labyrinthine, 414

Occlusion of posterior choanae, 548
Occupation and aural disease, 20
Ocular signs in chronic suppurative otitis media, 227
Operations upon frontal sinus, 581
Organ of Corti, 442
Os orbiculare, 15, 159
Osseo-fibrous meatus, 7
Osseous labyrinth, 433
  meatus, foreign bodies in, 114
    fracture of, 74
  portion of Eustachian tube, 155
  tumours in external auditory meatus, 137
Ossicles, articulations of, 159
  caries and necrosis of, 217
  indications for removal of, 217
  ligaments of, 160
  movements of, 15
Ossiculectomy, 217
Osteo-chrondomata, 82
Osteoma of mastoid process, 83
  nasal, 537
Osteomyelitis of mastoid process, 309
Osteo-sclerosis of mastoid process, 166
Ostium maxillare, irrigation through, 573
Othaematoma of auricle, 108
  spontaneous, 108
  traumatic, 109
Otitis externa circumscripta, 126
    crouposa, 133
    diffusa, 130
    diphtheritica, 134
    haemorrhagica, 131
    parasitica, 135
  interna, 476
  media, aetiology of, 175
    bacteria in discharge, 223
    catarrhalis, 175
    catarrhalis chronica, 187
    cytology of discharge, 244
    diagnosis of, 178
    in influenza, 301
    objective indications of, 178
    operative treatment of, 195
    pathology of, 176
    prognosis of, 178
    serosa, 175
    suppurativa acuta, 198
      chronica 221
        bacteria in discharge, 200
        cytology of, 200
Otitis media, symptoms of, 176
    treatment of, 179, 192
    tuberculosa, 287
Otoliths, 438
Oto-mycosis, 135
Oto-sclerosis, 465
  Paracusis Willisii in, 470
  pathological changes in, 467
  tuning-fork tests in, 470
Outer attic wall, 216
Outstanding auricle, 70
Oxyakoia Willisii, 355
Ozaena, 526

Pachymeningitis externa circumscripta, 371
  interna, 371
Palate retractor, White's, 63
Panotitis, 480
Panse's flap, 330
Papilloma of auditory meatus, 80
  nasal, 535
Paracentesis knife, 206
Paracusis loci, 55
  Willisii, 54, 177, 470
Paralysis of acoustic nerve, 507
  of external rectus muscle, 374
  of facial nerve, 352
Parasitic inflammation of auditory meatus, 135
Pars flaccida (*v.* Shrapnell's membrane), 212
  promontoria, 152, 479
Passow-Trautmann operation, 346
Pelvis ovalis, 435
Perichondritis of auricle, 111
Periostitis of mastoid process, primary, 305
  secondary, 305
Perisinous abscess, 421
Petro-mastoid, development of, 164
Petro-squamosal sinus, 11, 376
  suture, 368
Petrous bone, triangular area of, 398
Pfeiffer's bacillus, 258
Pharyngoscope, 64
Pharynx, examination of, 58
Phénomène d'éventail, 401
Phlebitis of sigmoid sinus, 419
  operative treatment of, 426
Physiology of sound-conducting and perceiving apparatus, 13
Pifll's operation, 430
Plasma cells, 250
Plastic flaps in radical mastoid operations, 329
  operations for closure of retro-auricular fistula, 344
Pneumatic mastoid process, 305
  speculum, Siegle's, 25
Pneumococcus, 254
Pneumo-massage, 53
Polypi, aural, 264
  avulsion of, 271
  forceps for removal of, 271

Polypi, removal of, with instruments, 270
  snare for removal of, 271
  structure of, 265
  treatment of, by alcoholic bath, 269
    by application of caustics, 268
    by electro-cauterisation, 270
    by interstitial injections, 270
Politzer's acoumeter, 30
  bag, 42
  method of inflation, 42
Polypus of nose, 533
Pontine tumours, 501
Porus acusticus, 506
Posterior ethmoidal cells, suppuration of, 584
  rhinoscopy, 61
  turbinectomy, 524
Post-nasal catarrh, 549
Post-suppurative residua, 238
Primary periostitis of mastoid process, 305
Processus brevis, 29
  caudalis, 4
  cochleariformis, 153
  styloidea, 156
  uncinatus, 61
Protector, Stacke's, 334
Prussak's space, 213
  suppuration in, 213
Pseudo-Menière symptoms, 458
Ptosis, 380
Purulent rhinitis, 519
Pus-seeker, Horsley's, 406

Quantitative tests for hearing, 32
Quincke's lumbar puncture, 385
Quinine deafness, 454
  use of, in Menière's disease, 457

Radical mastoid operation, 323
  after treatment of, 333
Recessus labyrinthi, 1
  tympanicus sub-aqueductu Fallopii, 335
Reflector, 23
Reisner's membrane, 439, 441
Removal of adenoids, 554
  of inferior turbinals, 524
Retro-auricular fistula, operations for closure of, 344
Retropharyngeal abscess, 315
Rhinitis atrophica, 526
  caseosa, 531
  chronic catarrhal, 521
  sicca, 526
  sicca non-foetida, 530
Rhinoliths, 547
Rhinoscopy anterior, 60
  median, 570
  posterior, 61
Rhode's audiphone, 243
Rinné's test, 36
Rivinian segment, 151
Rods of Corti, 443
Rombergism, 487
Rotatory nystagmus, 452
Rotation tests (labyrinth), 452
Rudimentary auricle, 66
Rupture of membrana tympani, 170
  medico-legal importance of, 173

Saccule, 437
Saccus endolymphaticus, 1, 2
Santorini, fissures of, 3
Sarcoma of auricle, 86
  of middle ear, 349
Scala tympani, 434
  vestibuli, 434
Scarlatinal-diphtheritic otitis media, 301
Scarlatinal - diphtheritic suppuration of middle ear, 301
Scarpa's membrane, 15
Schwabach's tuning-fork test, 34
Schwartze-Stacke operation, 323
Sebaceous cyst of auricle, 77
Secondary periostitis of mastoid process, 305
Semicircular canals, 435
Sensory aphasia, 403
Septal spur, 538
Sequestra from internal ear, 483
Serous cyst of auricle, 78
  meningitis, 384
Shrapnell's membrane, anatomy of, 158
  membrane, perforation of, 212
Siebenmann's plastic operation, 331
Siegle's pneumatic speculum, 25
Sigmoid sinus, 367
  groove, 367
Simulated deafness, 512
Sinus petrosquamosus, 11, 376
  phlebitis, 419
  thrombosis, 419
  tympani, 433
  tympanicus, 435
Skin-grafting, 336
Sondermann's suction apparatus, 53, 207
Specula, aural, 24
  nasal, 60
Speech test, 31
Sphenoidal sinus, suppuration of, 584
Spirochaetae, 255
Spirochaeta pallida, 276
Spontaneous haemorrhage from auditory meatus, 132
  haematoma of auricle, 108
Spur, facial, 326
  septum nasi, 538
Stacke's plastic flap, 330
  mastoid operation, 333
  protector, 327, 334
Stapes, 159
  accidental luxation of, 328
  anchylosis of, 468
  extraction of, 220, 474
  mobilisation of, 473
Stapedius muscle, 16, 161

Stapedius muscle, motor supply of, 163
  tenotomy of, 197
Staphylococcus epidermidis albus, 320
Stenger's test, 513
Streptococci, 257
Stria vascularis, 442
Stricture of external auditory meatus, 143
  of Eustachian tube, 185
Styloid process, 156
Subarachnoid cisterna, 383
Subdural space, drainage of, 381
Submucous nasopharyngeal emphysema, 47
  resection operation, 542
Superior vestibulotomy, 492
Suppuration from nasal accessory sinuses, 568
  of anterior ethmoidal cells, 575
  of frontal sinuses, 577
  of labyrinth, 480
  of posterior ethmoidal cells, 584
  of sphenoidal sinus, 584
Suprameatal spine, 317
  triangle, 317, 324
Syncitial cells, 249, 274
Syncytium, auditory, 446
Syphilis of auricle, 105
Syphilitic granuloma, 275
  labyrinthitis, 460
  middle-ear disease, 350

Tabes dorsalis, 501
Tâche cérébrale, 380
Tampons, artificial, 241, 242
Tegmen tympani, 148
  antri, 148
Telephone operators, ear disease in, 21
Temporal bone, infantile type of, 165
Temporo-sphenoidal abscess, 400
  decompression, 382
Tensor tympani muscle, 16, 161
  tenotomy of, 196
Thrombosis, of internal jugular vein, 419
  of jugular bulb, 430
  of sigmoid sinus, 424
Tinnitus, 361
Tonsil and adenoid operations, anaesthetics in, 566
  haemorrhage in, 565
Tonsillotomy rash, 565
Tonsils, enucleation of, 559
  hypertrophy of, 558
  removal of, 559
Tophi, 87
Toynbee's artificial tympanum, 241
Tractus spiralis foraminulentus, 435
Tragus accessory. *See* Auricle, malformation of, 66
Transillumination, 571
Traumatic Haematoma, 109
  deformities of external ear, 67
  membranous rhinitis, 520
  rupture of membrana tympani, 170
Triangular area of petrous bone, 398
  cartilage, dislocation of, 540
Tröltsch's aural hook, 117
  pouches, 158
Tubercle bacilli in discharge from ear, 294
  in brain abscess, 392
Tuberculoma, 275
Tuberculous disease of middle ear, 287
  channels of infection, 287
  facial paralysis in, 290
  primary, 287
  secondary, 288
Tumours, extracerebellar, 500
  intracerebellar, 501
  of cerebral cortex, 499
  of lateral cerebellar lobe, 500
  of nasopharynx, 556
  of the cerebellum, 500
  of the pons, 501
  of the vermis, 501
Tuning forks, 33
  practical value of, 37
Turbinectomy, anterior, 524
  posterior, 524
Turck's tongue depressor, 60
Tympanic epithelium, 247
  membrane, arterial supply of, 151
      deformities of, 68
    embryonic gelatinous tissue in, 156
    lining membrane of, 156
  membrane, 150
    nerves of, 151
Tympanum, arteries of, 161
  motor neuroses of, 364
  nerves of, 163
  pouches of, 157
  physiology of, 14
  veins of, 162
Typhoid fever, ear affections in, 299, 300

Umbo, 29
Uniform acoumetric formula, 38
Utricle, 437

Vaccine therapy, 298
Valsalva's method of inflation, 41
  therapeutic value of, 42
Vermis, tumours of, 501
Vertigo ab aure laesa, 486
Vestibular apparatus, function of, 434
  nerve, 444
Vestibulotomy, inferior, 493
Vicarious haemorrhage from auditory meatus, 132
Von Pirquet's cuti-reaction, 295
Voss's operation upon sigmoid sinus, 430

Wassermann's test for syphilis, 463
Watch tests, 32
Waugh's operation (tonsils), 560
Weber-Liel's intratympanic tube, 52
Weber's test, 35

Weichselbaum's diplococcus, 387
West's operation (tonsils), 559
West and Scott's operation (labyrinth), 492
Whispered speech, testing with, 31
White's palate retractor, 63
Whiting's encephaloscope, 407
Wilde's incision, 308, 317
Wingrave's cannula, 58
  polypus forceps, 271
Wingrave's syringe, 27
Wolf's operation, 335
Word-deafness, 497
Wright's hypertonic solution, 315

X-rays in diseases of the ear, 104

Zona arcuata, 441
  pectinata, 441

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Printed by R. & R. Clark, Limited, *Edinburgh*.

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